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Sky at Night

AUGUST 2018

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- ✦ All the info you need to observe, image and record
- ✦ **PLUS** How to find meteorites at home

Watch the lunar **ECLIPSE**

Where to look, when to look and what to
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Discover the latest
from NASA's Juno
mission at Jupiter

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How the space probe is
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This month's contributors include...

Will Gater

Astronomy author



It's always good to get advice from experts, and Will's been

encouraging them to give up their astro secrets. Page 64

Elizabeth Pearson

News editor



Elizabeth learns that there are lots of ways to be more

proactive when viewing meteor showers like the Perseids. Page 34

Niamh Shaw

Space writer



Niamh has spent time in a Mars sim habitat so who better

to write about the Martian analogue missions taking place globally? Page 70

Andrew Steele

Astrobiologist



As part of the team that recently discovered Martian

organisms, Andrew has a new approach to finding life on Mars. Page 19

Welcome

Discover the best ways to get the most out of meteor showers



This month on its orbit round the Sun, Earth passes through the trail of debris left in space by comet 109P/Swift-Tuttle. As the tiny grains of dust in the 26km-

diameter comet's trail strike the molecules in our atmosphere, they create white hot streaks of light that make up the Perseid meteor shower. This year's event promises to be especially good as it coincides with a new Moon: the absence of bright lunar light will make the shooting stars particularly visible. With full observing details on page 50 and a detailed walkthrough of photographing the shower on page 62, make this the year you set a record for most meteors observed.

It's not only visual observations that you can do. On page 34 you'll also find Elizabeth Pearson's complete guide to the different ways it's possible to track a meteor shower at home – including a look at how to search for micrometeorites.

Elsewhere, on page 65 Will Gater speaks to experienced amateur astronomers to learn their top tips for the most useful things they've learned over the years. The feature is full of useful things they think every astronomer should know.

And on page 41 Ben Skuse hears from professional astronomers about the future of space telescopes. As we reach the upper

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limits on the size of reflecting telescopes like Hubble we can launch into orbit, scientists and engineers are thinking of radical new ways of collecting and focusing light from the very furthest reaches of the cosmos.

Enjoy the issue!

Chris Bramley Editor

PS Our next issue goes on sale 23 August.

Sky at Night Lots of ways to enjoy the night sky...



TELEVISION

Find out what *The Sky at Night* team will be exploring in this month's episode on page 17



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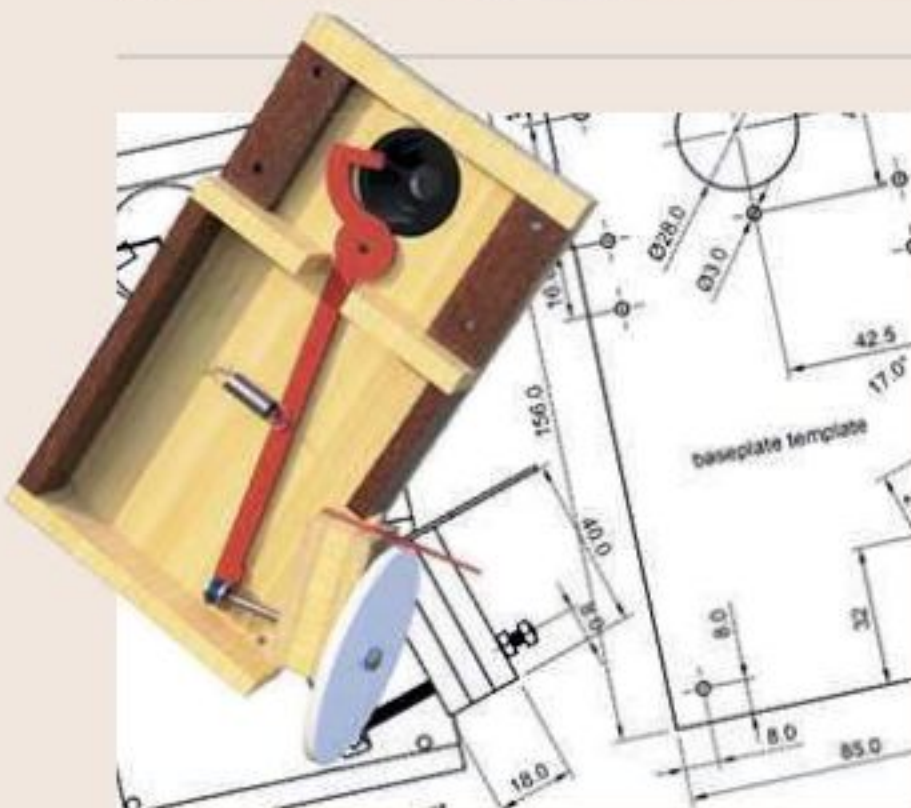
THERE'S
MORE
ONLINE

August highlights

Watch *The Sky at Night*



NASA has announced an extension to the Juno mission around Jupiter, meaning the spacecraft will have even more time to uncover the secrets of this iconic gas giant. In this episode, Maggie finds out some of Juno's greatest discoveries so far, while Pete Lawrence reveals how amateur astronomers can play a role in the study of Jupiter.



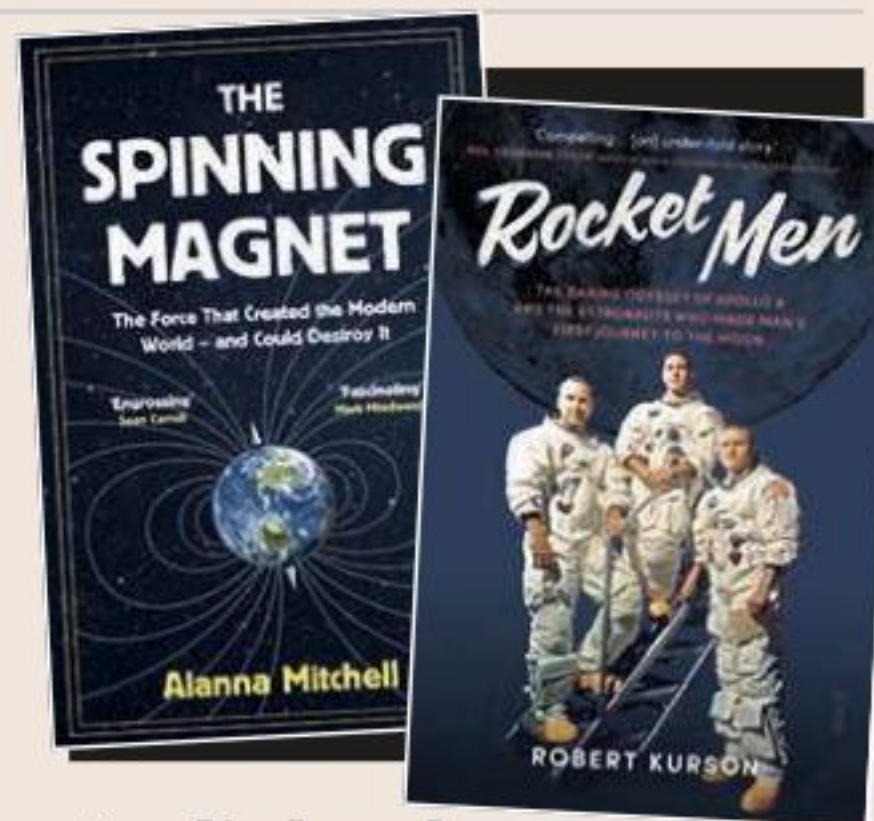
How to make a double star eyepiece

Access plans, diagrams and additional images to help with this month's *How To* project on page 80.



What's next for New Horizons?

The spacecraft has awoken after months in hibernation. Project scientist Hal Weaver discusses its upcoming flyby.



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Download excerpts from new audiobooks on planetary magnetism and the Apollo 8 mission.

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EVERY MONTH
Virtual Planetarium
With Paul Abel and Pete Lawrence
Explore August's night-sky highlights with Paul and Pete

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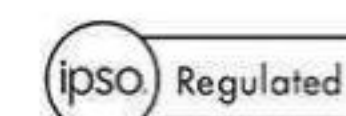
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Web of stardust

The astronomical arachnid sparkles in this newly captured image revealing patches of nebulosity and scorching hot stars

VERY LARGE TELESCOPE SURVEY TELESCOPE, 30 MAY 2018

Nebulae are some of the most chaotic, dynamic and beautiful objects we know of in the Universe. These glowing clouds of cosmic dust and gas are illuminated by the light of hot stars and, like meteorological clouds on Earth, often form familiar-looking shapes.

This is NGC 2070, otherwise known as the Tarantula Nebula, pictured in the most crisp image of it that's ever been taken. The nebula was discovered in the 18th century and was later given its nickname due to the bright patches of nebulosity that some observers think make it look like a large spider.

This beautiful object spans over 1,000 lightyears and is found in the Large Magellanic Cloud, a neighbouring galaxy of the Milky Way. The nebula is certainly an eventful region of the cosmos, containing the remnants of exploded stars, glowing gas clouds and sparkling star clusters. It's home to huge stellar specimens, some of which are over 300 times the mass of our Sun.

ESO

Rose from a galactic crash

HUBBLE SPACE TELESCOPE, 31 MAY 2018

This flower-like galaxy, known as NGC 3256, is the result of a violent crash between two spiral galaxies that occurred 500 million years ago. The effects of this collision can still be seen in the extended luminous tails that stretch outwards. The colliding cosmic dust generates the birth of a vast amount of stars at its centre, making it a 'starburst' galaxy.



Secrets spill into space ►

ATACAMA LARGE MILLIMETER/
SUBMILLIMETER ARRAY, VERY LARGE
TELESCOPE, 28 MAY 2018

Cosmic material within galaxy NGC 5643 falls into a supermassive black hole its centre, but observing this process is tricky as the galaxy's core is obscured by clouds of dust. However, in this image the combined power of two telescopes reveals blue outflows either side of the galaxy, a result of matter being ejected from the accretion disc of the black hole.

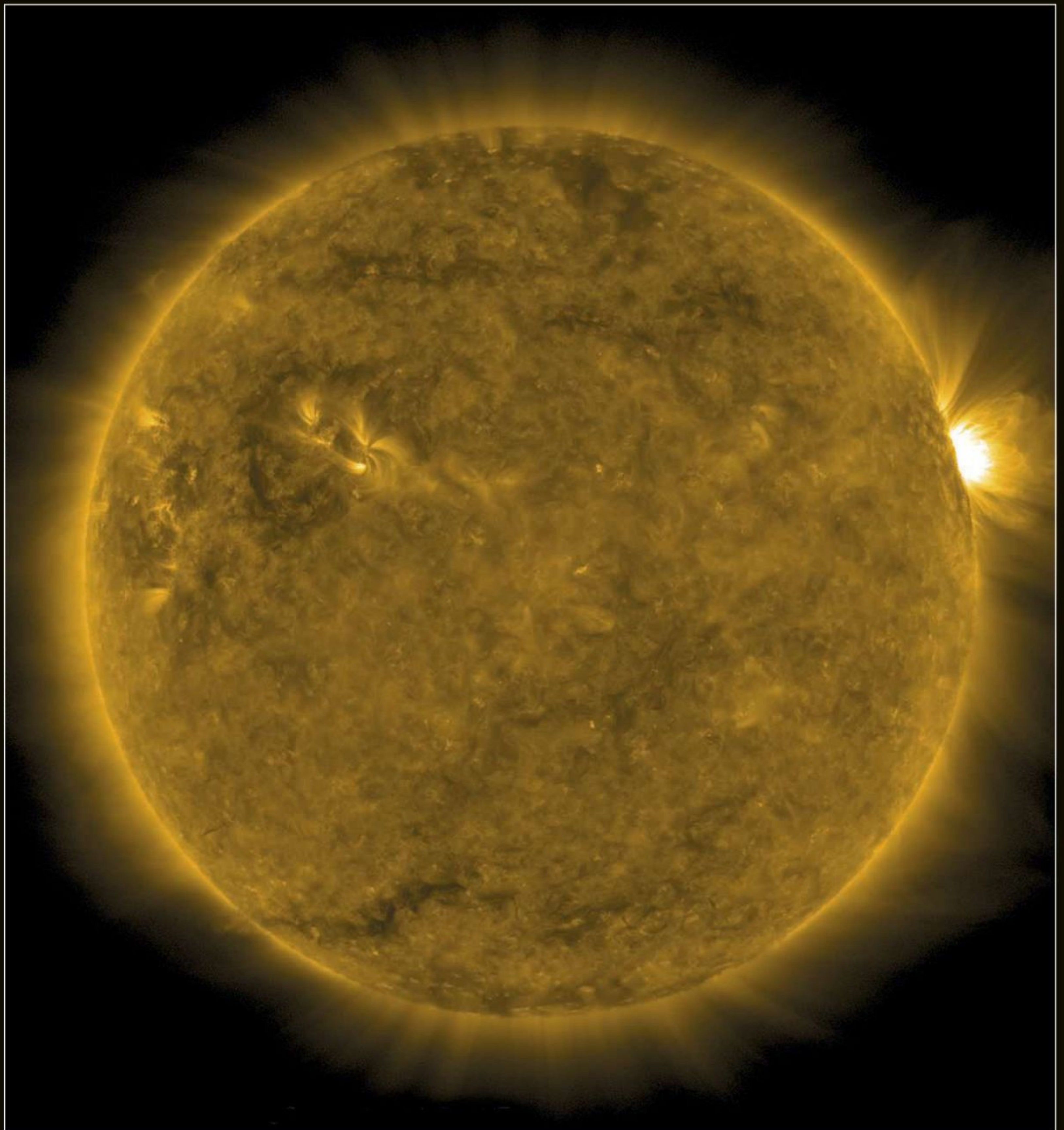




▲ Cyclone saturation

JUNO SPACECRAFT,
24 MAY 2018

The storms of Jupiter stretch right across the gas giant's surface, as can be seen in this image captured 7,900km from the cloud tops. To the left of the prominent grey band of central cyclones is the North Temperate Belt, an orange streak of storms that rotates in the same direction as Jupiter itself.



▲ A look at the loops

NASA SOLAR DYNAMIC OBSERVATORY, 5 JUNE 2018

Coronal loops had never been seen in such detail before NASA's Solar Dynamic Observatory mission. The orbiting solar observatory was launched in 2010 and constantly captures images and data from our host star. The loops seen here are generated by electrified plasma flowing along magnetic field lines around the Sun.

YOUR BONUS CONTENT

A gallery of these and more stunning space images

CHIHUAHUA:



📍 Basaseachi Waterfall, Chihuahua

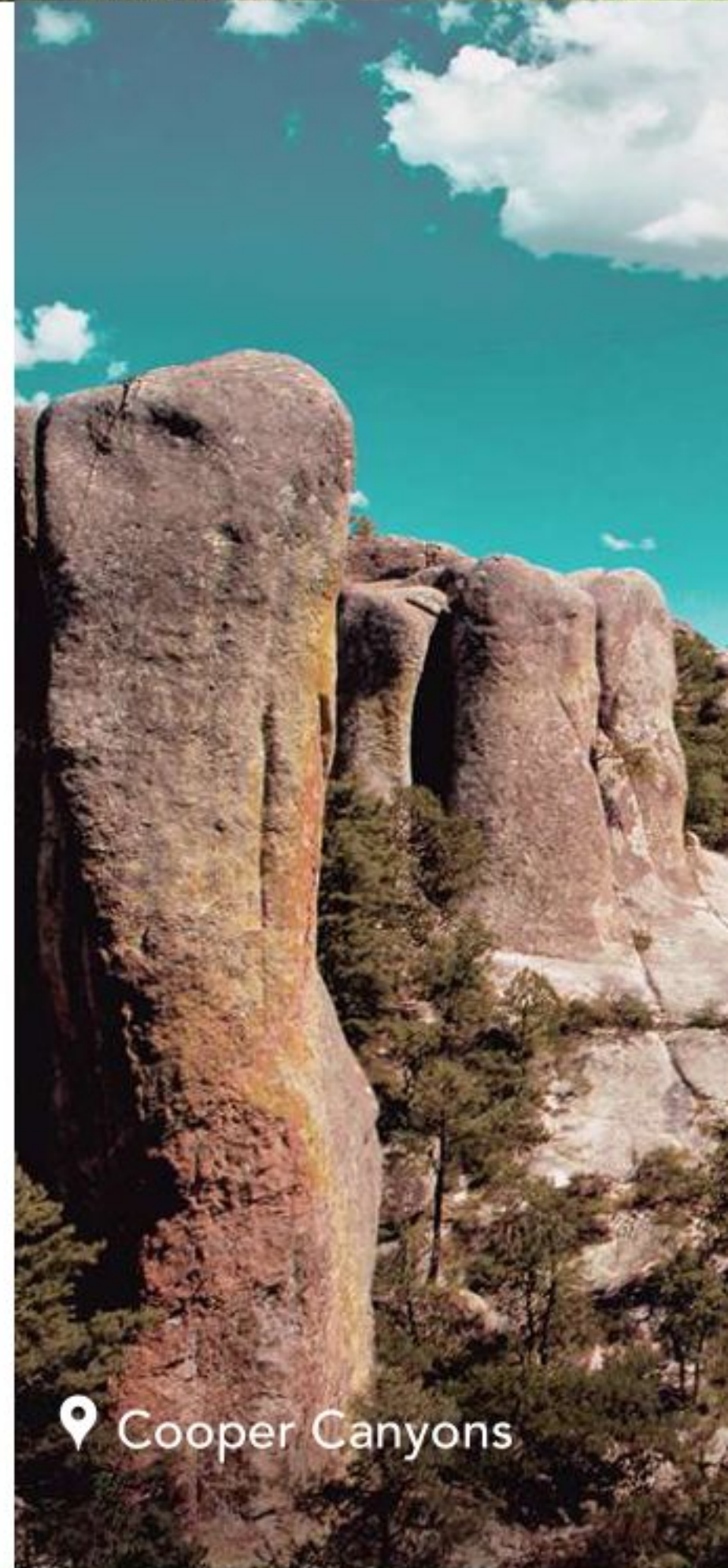
AN ORGANIC CIVILIZATION

Chihuahua is the largest state in Mexico, its greatness offers a diverse array of landscapes, from deserts to forest paradises. With the imposing and marvellous Sierra Madre Occidental mountains as the central inspiration for hundreds of tourists, Chihuahua is a first-class destination filled with adventures from the deepest caves to majestic canyons.

Located 247 kilometres southeast of the city of Chihuahua, on the upper reaches of the Sierra Madre Occidental, lies Creel, surrounded by forests, rocks, caves, lakes, waterfalls, rivers, the spectacular Copper Canyons, and the missions and traditions of the Tarahumara - or Rarámuri, as they call themselves - culture. This magnificent town is also the passage of the Chihuahua Pacífico train, better known as Chepe.

Immersing yourself in the Rarámuri culture during your stay is easy: visit San Ignacio Arareko, only 8 kilometres from Creel. Here, you'll discover the most traditional Rarámuri craft: basketry - although Rarámuris have also shown great expertise in carved wood products, decorative objects and furniture, clay objects and wool articles. These pieces can be found in the Museum or House of Handicrafts, an essential stop through your journey.

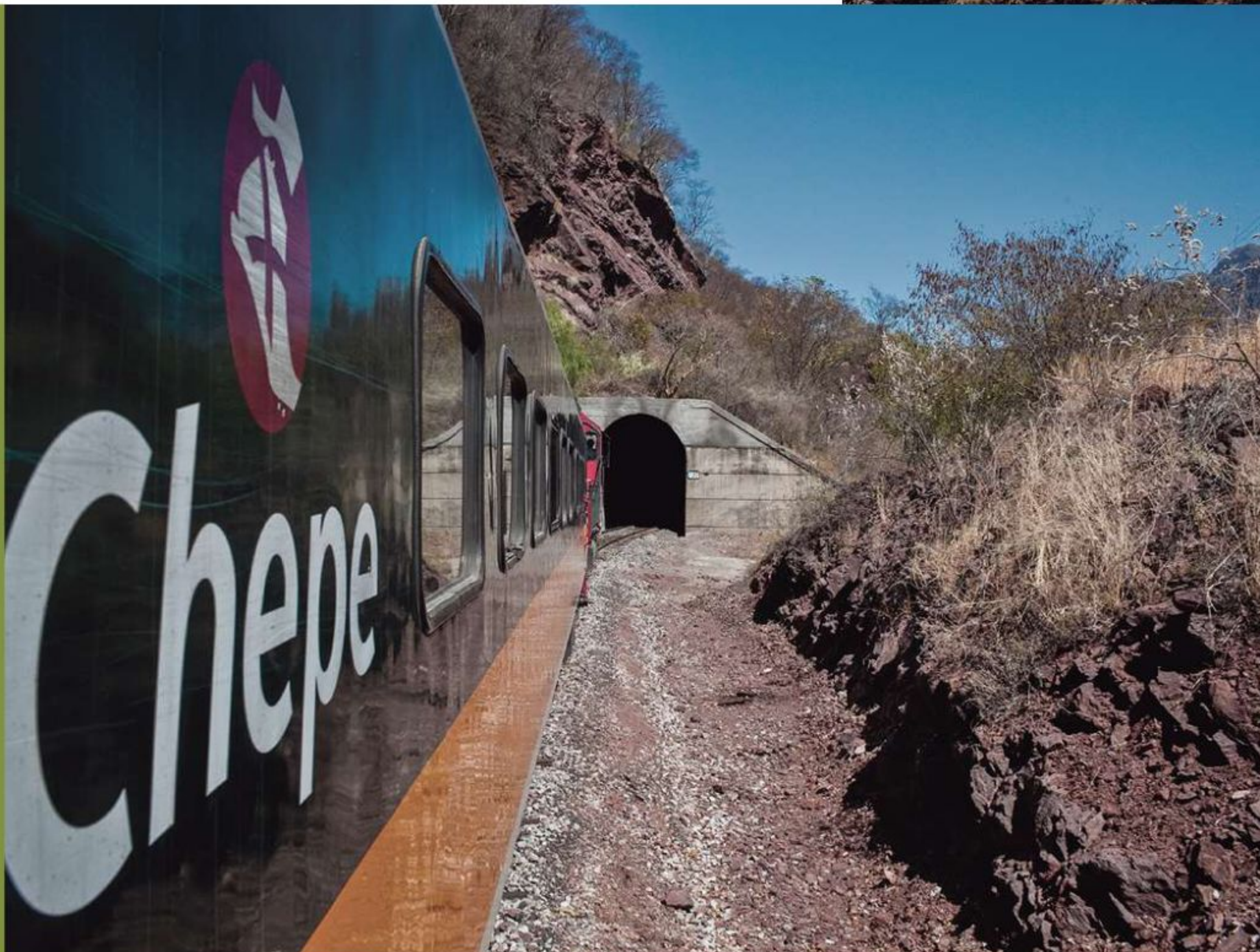
Rukiraso Waterfall is one of Chihuahua's most majestic natural attractions; you can take a walk through the caves nearby in order to admire ancient cave paintings; however, there is also the Basaseachi Waterfall, which will take you through the forest of this beautiful region.



📍 Cooper Canyons

THE CHIHUAHUA PACÍFICO TRAIN:

On May 17, 2018, the new Chepe Express began operating. This luxurious train is composed of nine passenger cars, which were designed to make the viewing of landscapes of the area an unparalleled experience. There is a terrace, a bar and a two-storey dome car that houses the Urike restaurant (in reference to the deepest canyon of the Sierra Tarahumara). The restaurant car offers an experience of Mexican cuisine coupled with French touches, Mennonite dairy products and local fruits. El Chepe is the ideal way to visit one of the most imposing natural settings in Mexico: The Copper Canyons.



ADVENTURE PARK

The Copper Canyons, with 60,000 kilometres of mountains are one of the longest systems in the world and one with the most impressive zip lines in Mexico. Rivers, trails, mountains, and the Rarámuri culture coexist in the vicinity of the Chepe train station. Also intertwined with nature is The Divisadero, a set of 7 zip lines and 2 suspension bridges that add almost 5 kilometres of route. In one of Mexico's most impressive adventure parks you can enjoy rock climbing or bungee jump from a small suspension bridge into a 400m abyss.

Paquimé, located in Casas Grandes, in the northwest of the state of Chihuahua, is an ancient architectural wonder. Most of the pre-Hispanic archaeological sites of Mexico are similar because they usually have large or medium pyramids, palaces, open plazas, traditional "ball game" courts, tombs, sculptures carved in stone, and buildings used to observe the stars. However, Paquimé is totally different: surprising for its urbanization, it is an archaeological wonder made of thick adobe walls that project a striking game of shadows illuminated by the intense rays of the sun. Archaeologists believe that this site holds the remains of at least two thousand rooms.

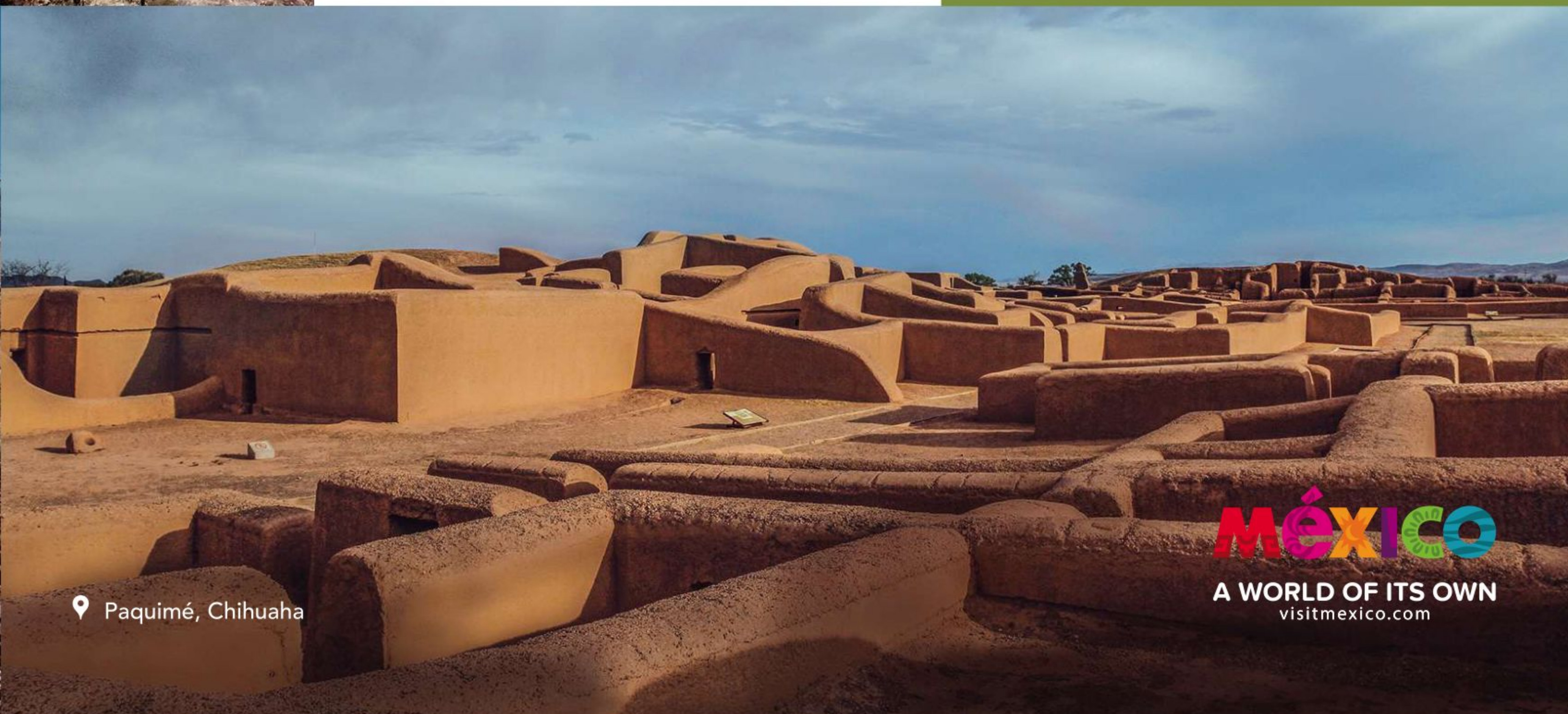
With so many adventures at your fingertips, the question is not whether you're interested in coming; the question is:

HOW FAR WILL YOU GO?



Batopilas, Chihuahua

Batopilas is a town in the state of Chihuahua, located right in the middle of the spectacular Sierra Tarahumara. It will surprise you with its beautiful buildings and its brilliant past - a product of the silver extracted from its mines. The town's beauty is mirrored by that of the canyon and everything that surrounds it: ravines, rivers, exotic trees, amazing flowers and birds.



Paquimé, Chihuahua

Bulletin

The latest astronomy and space news written by **Elizabeth Pearson**

PLUS
CUTTING

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EDGE

Our experts examine the hottest new astronomy research papers



COMMENT

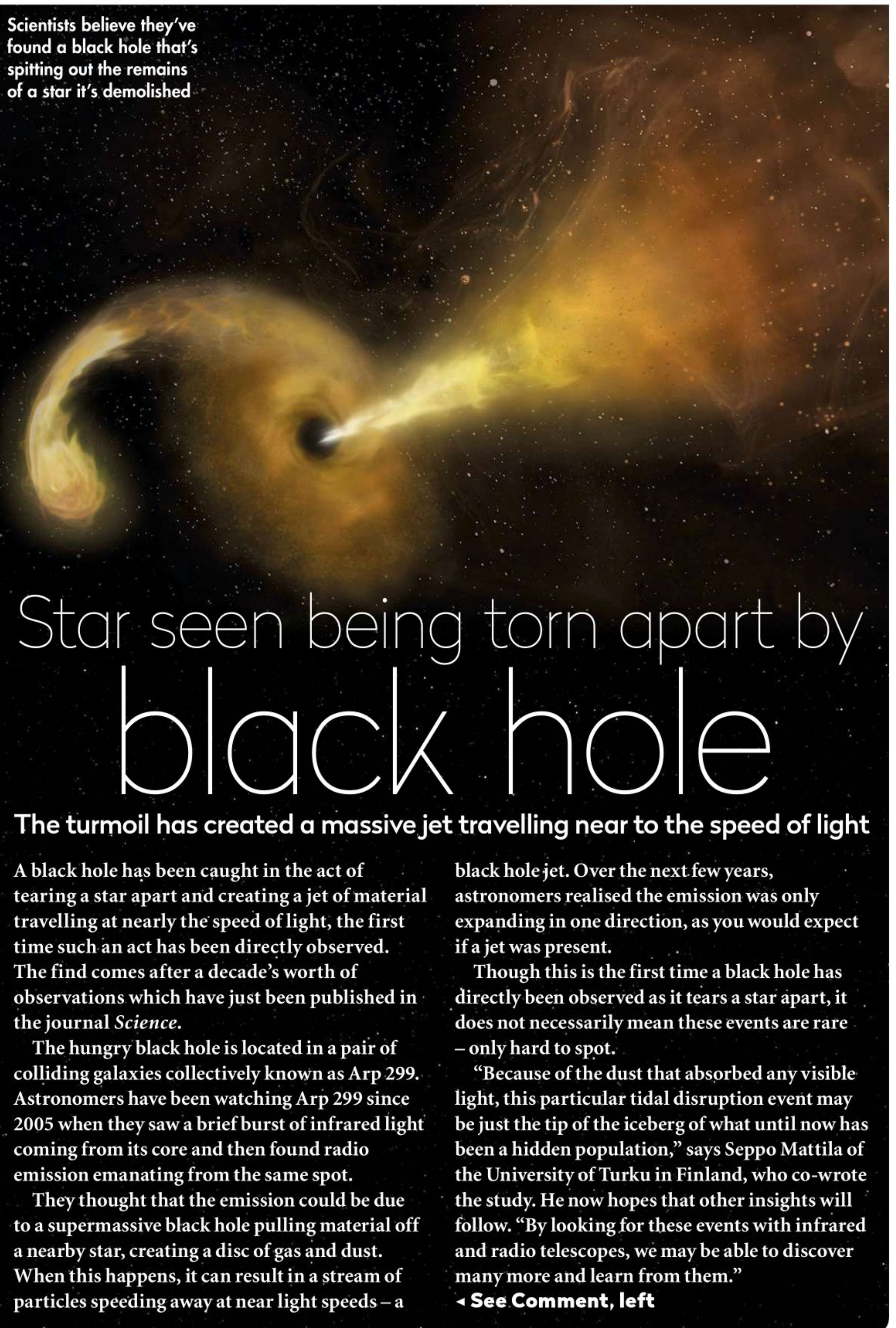
by Chris Lintott

Observations like these are a reminder of the immense power of gravity, which is capable of powering some of the Universe's most dramatic events. In fact, the only reason we can currently detect them is because of the immense energies involved. Accelerating material in order to produce the radio jet seen in this single event requires a hundred million billion billion billion joules of kinetic energy – equivalent to the output of a Sun-like star over nearly a billion billion years!

The numbers are staggering, and that's my point. When we look at the sky, it's easy to believe that the important stuff is that which generates visible light. In fact, as recent discoveries such as the detection of gravitational waves have taught us, the real action lies elsewhere – where a black hole can rip a star apart in a flash, and where the dance of these massive bodies twists the space around them.

CHRIS LINTOTT co-presents *The Sky at Night*

Scientists believe they've found a black hole that's spitting out the remains of a star it's demolished



Star seen being torn apart by black hole

The turmoil has created a massive jet travelling near to the speed of light

A black hole has been caught in the act of tearing a star apart and creating a jet of material travelling at nearly the speed of light, the first time such an act has been directly observed. The find comes after a decade's worth of observations which have just been published in the journal *Science*.

The hungry black hole is located in a pair of colliding galaxies collectively known as Arp 299. Astronomers have been watching Arp 299 since 2005 when they saw a brief burst of infrared light coming from its core and then found radio emission emanating from the same spot.

They thought that the emission could be due to a supermassive black hole pulling material off a nearby star, creating a disc of gas and dust. When this happens, it can result in a stream of particles speeding away at near light speeds – a

black hole jet. Over the next few years, astronomers realised the emission was only expanding in one direction, as you would expect if a jet was present.

Though this is the first time a black hole has directly been observed as it tears a star apart, it does not necessarily mean these events are rare – only hard to spot.

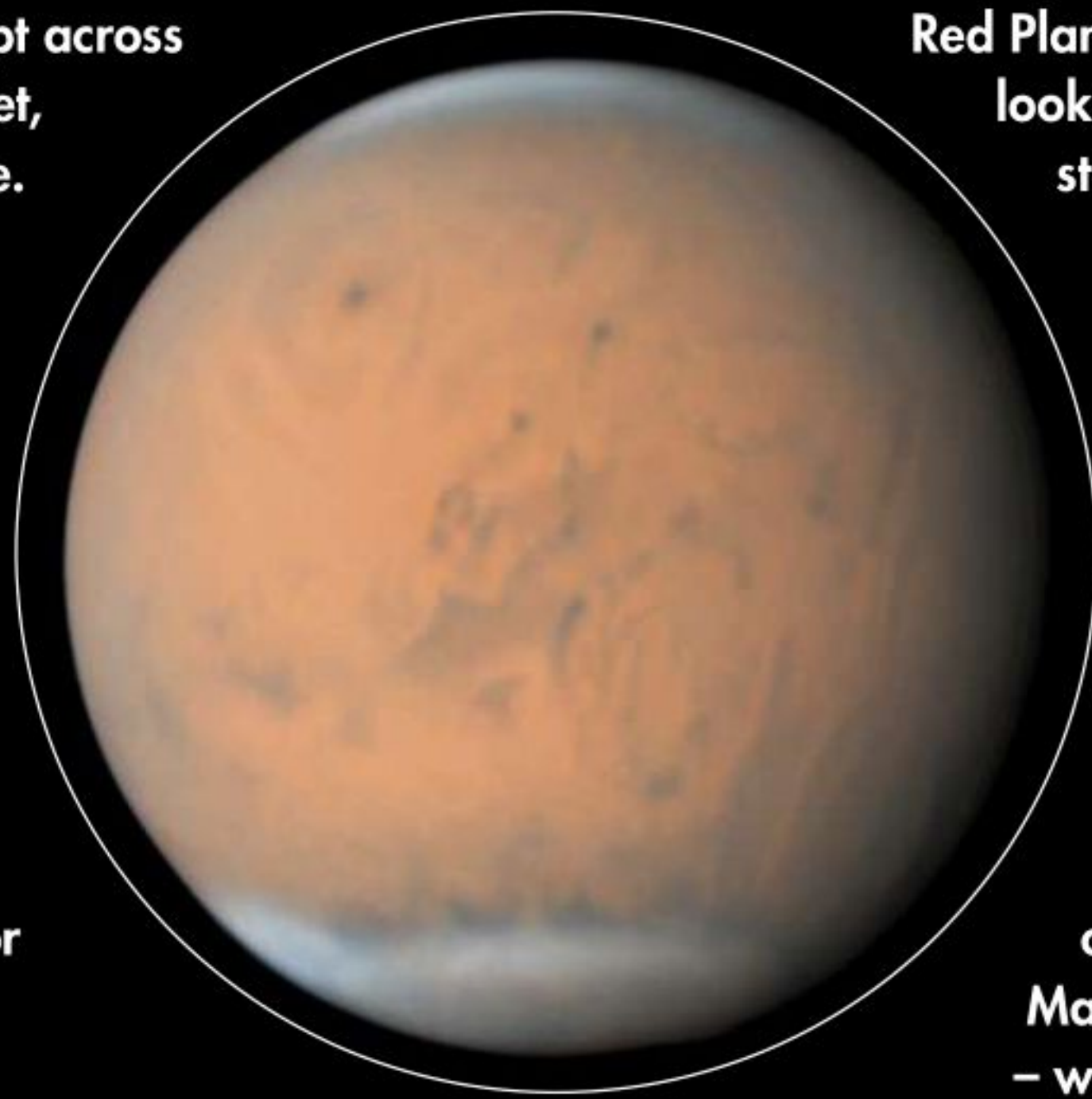
“Because of the dust that absorbed any visible light, this particular tidal disruption event may be just the tip of the iceberg of what until now has been a hidden population,” says Seppo Mattila of the University of Turku in Finland, who co-wrote the study. He now hopes that other insights will follow. “By looking for these events with infrared and radio telescopes, we may be able to discover many more and learn from them.”

◀ See Comment, left

Global storm blows across Mars

A huge dust storm has swept across the entirety of the Red Planet, and went global on 20 June. Storms this large can last for months at a time and happen every few Martian years (around once an Earth decade), but this time the storm will be closely watched by three orbiting spacecraft and the Curiosity rover.

"This is the ideal storm for Mars science," says Jim Watzin, director of NASA's Mars Exploration Program. "We have a historic number of spacecraft operating at the



▲ An image of Mars taken on 28 June shows its prominent features obscured by the dust storm

Red Planet. Each offers a unique look at how Martian dust storms form and behave – knowledge that will be essential for future robotic and human missions."

Curiosity has already measured the highest atmospheric opacity that the rover has ever seen as the dust blots out the Sun. Unfortunately, this has meant that the other currently operational Martian rover, Opportunity – which uses solar panels for power – has been forced to shut down until the storm passes. mars.nasa.gov

NEWS IN BRIEF



DO EXOMOONS HARBOUR LIFE?

A new study has identified 121 giant exoplanets that lie in their stars' habitable zones and could have moons capable of supporting life. Even though the planets are unlikely to be habitable themselves, gas giants can have dozens of moons which could.

"Our follow-up studies will help inform future telescope design so we can detect these moons, study them and look for signs of life," says Michelle Hill from the University of Southern Queensland, which took part in the study.



NEW HORIZONS WAKES UP

NASA's New Horizons Probe, which flew past Pluto in 2015, re-awoke from hibernation on 5 June. It is now preparing to fly by the Kuiper belt object Ultima Thule on New Year's Day 2019. "Our team is already deep into planning and simulations of our upcoming flyby of Ultima Thule and excited that New Horizons is back in an active state and ready for flyby operations, which will begin in late August," says Alan Stern, the mission's Principal Investigator.

Stephen Hawking laid to rest

His ashes are interred at Westminster Abbey after memorial service

"No one since Einstein has done more to deepen our knowledge of the cosmos and inspire achievement against the odds."

Those were the words Lord Martin Rees, the Astronomer Royal, used to describe his friend, colleague and fellow scientist Professor Stephen Hawking at his memorial service on Friday 15 June. While his funeral, held on 31 March, was an understandably solemn affair, the memorial service was a colourful celebration of Hawking's life and work attended by friends, family, scientists, astronauts, actors (including Benedict Cumberbatch

who portrayed him in the 2004 TV movie *Hawking*) and hundreds of schoolchildren.

Before his death on 14 March 2018, aged 76, Hawking had garnered an unprecedented level of global recognition for his scientific discoveries and ability to popularise them. As his ashes were interred in Westminster Abbey between those of Isaac Newton and Charles Darwin, an audio recording of Hawking reading a tribute, set to music by the composer Vangelis, was beamed into space towards 1A 0620-00 – the nearest black hole to Earth.

www.hawking.org.uk



▲ Left: Tim Peake spoke at the memorial service. Right: Hawking's ashes are now buried at Westminster Abbey

NEWS IN BRIEF



SIGNS OF WATER IN LUNAR ROCK

Moganite, a mineral that needs water to form, has been found inside a lunar meteorite. It's the first time the mineral has been seen in lunar rock. "Moganite forms on Earth as a precipitate when alkaline water including silicon dioxide is evaporated under high pressure conditions," says Masahiro Kayama of Tohoku University, who made the discovery. "The existence of moganite strongly implies that there is water activity on the Moon."



EARLY DUST TRAPPED IN GLASS

Dust from the nebula that created our Solar System could have survived trapped inside comets. Planetary geologists from the University of Hawai'i at Manoa found the motes of dust trapped within glassy grains of comets, where they were protected from the processes that either destroyed or reworked almost all of the original nebula's dust. The team will continue to study these particles to understand the conditions that led to the birth of the planets.

MASAHIRO KAYAMA/TOHOKU UNIVERSITY, ISTOCK, NASA/JPL-CALTECH/MSSS

LIFE ON MARS?

Curiosity finds building blocks for life near the Martian surface

NASA's Curiosity rover has made two discoveries on Mars that give new hope to the hunt for life on the Red Planet. In June it was announced that not only had the rover found 3-billion-year-old organic material in rocks, it had also measured a seasonal change in current methane levels.

Curiosity found traces of organic chemicals (those containing both carbon and hydrogen) trapped in rocks within Gale Crater. These chemicals are thought to be vital ingredients for creating life and their discovery has encouraged those engaged in the search for life.

"Finding ancient organic molecules in the top five centimetres of rock that was deposited, when Mars may have been habitable, bodes well for us to learn the story of organic molecules on Mars with future missions that will drill deeper," says Jen Eigenbrode who led the study.

Curiosity has also been studying the Red Planet's atmosphere. Over the last three Martian years it has measured how Mars's methane levels change with the seasons, finding the levels are higher in summer and drop in winter.

There are several possible geological explanations for this change, such as rock chemistry that's affected by the changing

temperature, but scientists can't rule out the possibility of a biological origin.

"This is the first time we've seen something repeatable in the methane story, so it offers us a handle in understanding it," says Chris Webster from NASA's Jet Propulsion Laboratory, who led the methane study. "This is all possible because of Curiosity's longevity, which has allowed us to see the patterns in this seasonal 'breathing'."

While neither of these discoveries indicates explicitly that past or present life exists on Mars, they are an encouragement to keep looking.

"Curiosity has not determined the source of the organic molecules," says Eigenbrode. "Whether it holds a record of ancient life, was food for life or existed in the absence of life, organic matter in Martian materials holds chemical clues to planetary conditions and processes."

"Are there signs of life on Mars?" asks Michael Meyer, lead scientist of NASA's Mars Exploration Program. "We don't know, but these results tell us we are on the right track."

mars.nasa.gov

► **See Passion For Space on page 19 for more about the discovery of organic materials on Mars**



Curiosity's exploration of the Martian surface has revealed what could be signs of life

CUTTING

Our experts examine the
hottest new research

EDGE

How did the Owl get its shape?

Astronomers are struggling to explain the complexity of certain planetary nebulae



A 3D study of the Owl Nebula has revealed that it has two cones of gas extending from a central star

The beautifully sculpted shapes of planetary nebulae have long captivated astronomers. The transient remnants of dying Sun-like stars, these objects appear in modern images to be a long way from the indistinct discs recorded by the first deep-sky astronomers. In recent observations, especially those from the Hubble Space Telescope which made them some of its earliest science targets, they erupt in a riotous variety of forms.

Trying to understand these myriad shapes has given professional astronomers, who prefer things to be simple, something of a headache. Included amongst those sorting through the mess are a team from Mexico which has been looking at an object that might be familiar to many amateurs – M97, the Owl Nebula. It has a distinctive shape through telescopes or in pictures, but the team wanted to work out the 3D structure.

They can do that by identifying how different components of the gas are moving, and how the



CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project

features we see projected in two dimensions relate in 3D. Seen in this way, the ‘standard’ planetary nebula, if there is such a thing, is a bipolar outflow – two cones of gas expanding outward from a central star (think, for example, of the Dumbbell Nebula). Such a model simply doesn’t work for the Owl.

Instead, the team split one of the ‘lobes’ of the outflow into two, which move in different directions. That produces a sensible fit to the data, but leaves us with the puzzle of how such a complex structure formed. On smaller scales there is still more complexity: finger-like structures pointing away from the central white dwarf star and knots which clump in the expanding shells themselves.

Such a complex morphology is not unheard of amongst planetary nebulae, and it’s usually the result of the stellar wind from a young, vigorous star interfering with the surrounding gas. Here, though, the velocity of the expanding gas suggests the nebula itself is only 8,400 years old and, as we know how white dwarfs behave, this corresponds to

“The Owl Nebula, M97, has a distinctive shape through telescopes or in pictures but the team wanted to work out the 3D structure”

a less massive stellar progenitor which is now about five billion years old. We should expect no stellar wind from such an old star, and the structure seen in the Owl remains a mystery.

It isn’t quite alone, though. The researchers point to a handful of known examples in the local Universe of similarly aged stars with planetary nebula that share the appearance of M97, which they call strigiform (‘owl-shaped’), a term which I can imagine catching on. This newly identified class may have a transient existence, though; old stars like the one at the heart of M97 are likely to have little stellar wind with which to shape the surrounding nebulosity, and so the nebulae may be collapsing back in on themselves.

No such collapse has been detected, but it could be slow enough to remain hidden, while still being fast enough to explain why these things are rare. Observing and classifying planetary nebulae is an old game, but it still has plenty to tell us.

CHRIS LINTOTT was reading *The Owl and other strigiform nebulae: multipolar cavities within a filled shell* by Ma T García-Díaz, et al. **Read it online at** arxiv.org/abs/1806.04676

NEWS IN BRIEF



TRUMP FORMS SPACE FORCE

US President Donald Trump signed the National Space Policy Directive on 18 June. The policy calls for the creation of a sixth branch of the US military to defend the nation's space assets, which he calls the Space Force. However, the move still requires Congressional approval and has many critics, most notably those within the Pentagon who fear it would cause a schism within the Air Force, which currently operates most of the US's military space applications.



NEARBY STARS HABITABLE?

If there's a planet around the two main sequence stars of Alpha Centauri, Alpha Cen AB, it could host life. A recent study by the Chandra X-ray Observatory found the two stars emit a similar level of X-ray radiation to the Sun. This means it could be possible for life to survive on a planet found orbiting them, unlike their smaller sister the red dwarf Proxima Centauri, which would blast any orbiting world with 500 times more X-rays than Earth, effectively sterilising it.

ISTOCK; NASA/CXC/UNIV. OF COLORADO/T. AYRES ET AL.
PETER Z. HARRINGTON, S. D'AGNELLO/NRAO/AUI/NSF, NASA

Dust could be distorting views

Tiny particles might make active galactic nuclei look lopsided

Small clouds of dust could explain the odd behaviour astronomers have observed around active galactic nuclei (AGN), the bright regions formed by supermassive black holes pulling in and consuming the material that surrounds them.

Some AGNs appear to have regions that are highly changeable and asymmetrical, which has been a long-standing puzzle for astronomers. However, a new study suggests that small clouds of dust moving around the disc could block out or redden some of the light, creating the illusion of the AGN being lopsided.

"We think it's a much more natural explanation of the asymmetries and changes than other more exotic theories, such as binary black holes, that have been invoked to explain them," says Martin Gaskell from the University of California, Santa Cruz.

www.ucsc.edu



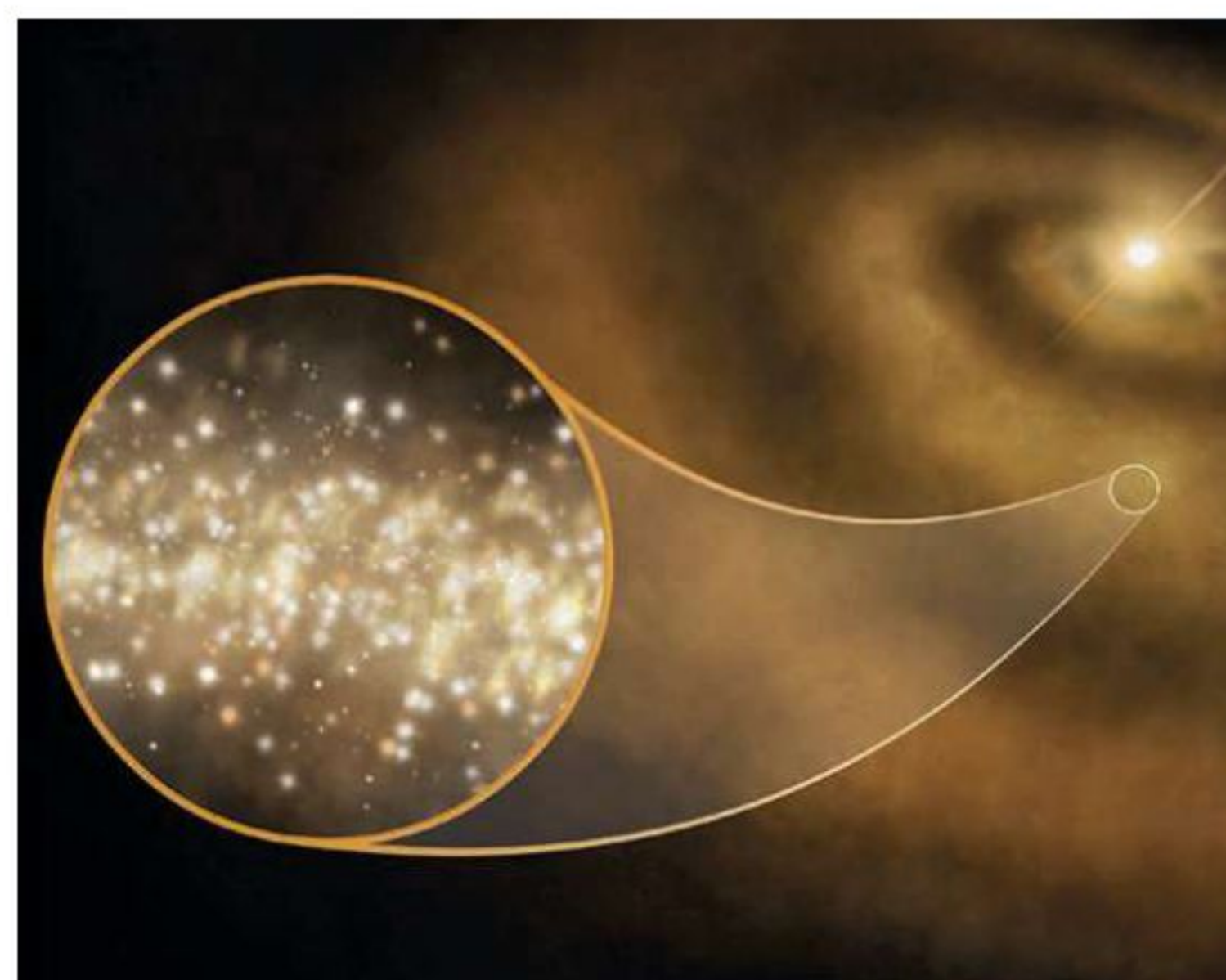
▲ Dust floating near active galactic nuclei might be obscuring and distorting some of the light they emit

Diamonds are a star's best friend

Clouds filled with diamonds could be responsible for strange microwave radiation seen emanating from young stars. Though the radiation has been observed for 20 years, astronomers were uncertain what could be causing it. But recent research says there's a good chance that tiny crystals of carbon, known as nanodiamonds, could form in the protoplanetary disc that surrounds newly formed stars and be responsible for the radiation.

"In a Sherlock Holmes-like method of eliminating all other causes, we can confidently say the best, and likely only, candidate capable of producing this microwave glow is the presence of nanodiamonds around these newly formed stars," says Jane Greaves of Cardiff University, who lead the study.

www.cardiff.ac.uk



▲ Tiny diamonds are likely to be what's making young stars 'sparkle' with mysterious microwave radiation

LOOKING BACK THE SKY AT NIGHT

6 August 1980

On the August 1980 episode of *The Sky at Night*, Patrick Moore looked at the work being done by the Pioneer Venus spacecraft. The probe arrived at Venus in December 1978, and had been mapping the planet's surface in the intervening months. As the thick atmosphere obscured conventional cameras, Pioneer Venus used radar to reveal a planet of vast plains, dotted with volcanoes and separated by mountains.

One surprising discovery Pioneer made was that Venus might have had some past tectonic activity. Parts of the terrain looked like subduction zones (where one plate slips under another) and mountains and valleys created by plate motion were seen. But if there had once been tectonic activity, it must have stopped a long time ago. The plains are heavily pockmarked by craters, meaning it has been billions of years since Venus has received the geological makeover that tectonics provide.



▲ NASA's Pioneer Venus Orbiter gave us new insights into the planet

CUTTING

Our experts examine the
hottest new research

EDGE

Sliproads for old satellites could prevent space pileups

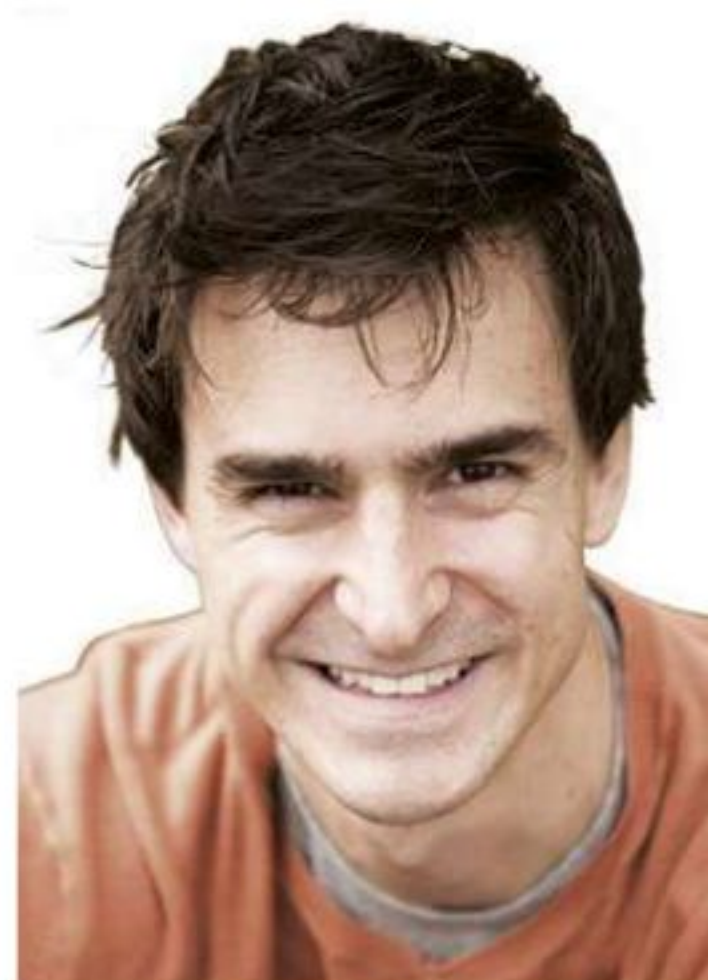
With the skies filling up with space junk, new ways need to be found to dispose of defunct satellites



Space is, ironically, getting a little crowded. At least, it is in certain orbital regions around the Earth. Humanity has been launching satellites around our planet with increasing enthusiasm for over 60 years now (ever since the Russians launched Sputnik 1 back in October 1957) and many of these objects have the potential to remain in orbit for a considerable time after they have reached the end of their operational lifetime. The concern is that these orbital regions are becoming dangerously cluttered and the risk of a satellite, or even a crewed space mission, being hit by a defunct cousin or other space debris is rising.

In the worst-case scenario, the cloud of high-speed shrapnel created by a collision would act like a shotgun blast, hitting and fragmenting more and more satellites in a destructive chain reaction, known as a collisional cascade. Such a disaster (which you might be familiar with from the sci-fi film *Gravity*) has been dubbed the Kessler Syndrome, after the NASA scientist who in the late 1970s warned of such a potential outcome. The result could fill an orbital region with so much

▲ Ryan Stone (Sandra Bullock) learns all about the Kessler Syndrome the hard way in the film *Gravity* (2013)



LEWIS DARTNELL is an astrobiology researcher at the University of Westminster and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

debris that it would make operating satellites impossible for many generations.

Elisa Maria Alessi and her colleagues at the Institute of Applied Physics in Florence, Italy, have been studying ways to ensure satellites safely deorbit and burn up in Earth's atmosphere at the end of their operational lifetime. Low Earth Orbit (LEO), covering an altitude range up to 2,000km, is the most critical region as it is here that most satellites, including the International Space Station, are positioned. LEO has been designated a 'protected region' by international agreement, and satellites are required to be safely disposed of by reentry within 25 years of the end of their operational phase. But, as Dr Alessi points out, most satellites in LEO aren't actually compliant with this stipulation. The problem is that it can actually require quite a lot of rocket propellant to shift an obsolete satellite into a lower orbit to be caught by atmospheric drag.

Dr Alessi has been running computer simulations of the most efficient ways to alter a satellite's orbit into the upper atmosphere in a reasonable time

"A collision could fill an orbital region with so much debris it would make operating satellites impossible for generations"

frame. Her solutions for such 'passive disposal' exploit a number of minor aspects of orbital dynamics, including the tiny force exerted on a satellite by sunlight or gravitational tugs from the Sun and Moon. These are subtle effects, but in certain circumstances can combine in what's known as a dynamical resonance, like the well-timed pushes on a child's swing leading to a large oscillation.

Alessi has mapped what she calls natural reentry corridors. With these, a satellite at the end of its lifetime need use only a relatively small amount of propellant to nudge it into such a deorbiting highway. Over time, resonance of these subtle dynamical effects will drive orbital decay and eventually plough the satellite into the upper atmosphere for it to burn-up safely.

In the future, Alessi says, satellites could be specifically launched into orbits with easy access to these reentry corridors for the end of their operational lifetimes, or be equipped with a sail-like device that it is deployed to increase the sunlight force and so ensure an even quicker disposal.

LEWIS DARTNELL was reading... *Natural highways for end-of-life solutions in the LEO region* by Elisa Maria Alessi et al. **Read it online at** <https://arxiv.org/abs/1805.05726>

What's on

Our pick of the best events from around the UK



Solarsphere 2018

Penmaenau Farm, Powys, 10-13 August

The astronomy and music festival returns to the Welsh countryside for another year. Solarsphere is a family-friendly star camp that welcomes beginners and expert astronomers, children and grown-ups. It includes deep-sky and solar observing sessions, science talks, live music, children's workshops, hot food, real ale and camping facilities. All evening events are held indoors to avoid light pollution.

This year's speakers include Professor Mark McCaughrean of the European Space Agency, astronomer and *BBC Sky at Night Magazine* contributor Will Gater, astrophysicists Dr Megan Argo and Dr Paul Roche, and Dr Suzanne Imber, who took part in the 2017 BBC

television series *Astronauts: Do You Have What It Takes?*

Astronomy educator Mary McIntyre hosts a workshop on lunar and solar sketching, while *BBC Sky at Night Magazine's* Steve Tonkin tells you how best to observe the night sky with binoculars. Cosmos Planetarium will provide a virtual tour of the Universe, while AstroCymru will host practical workshops throughout the weekend.

Tickets are £45 for adults, £20 for 13-16 year olds and free for under 13s. The price includes camping, access to the festival and some workshops.

For more information and to book tickets visit the Solarsphere website. www.solarsphere.events/index.html

BEHIND THE SCENES THE SKY AT NIGHT IN AUGUST

BBC Four, 12 August, 10pm (first repeat **BBC Four, 16 August, 7.30pm**)*



Set for launch in 2020, ESA's Solar Orbiter will study the Sun's surface up close

THE DEATH STAR

This month the team asks how much of a threat our Sun poses to life on Earth. Maggie and Chris explore Coronal Mass Ejections and why 'space weather' has never been much of a threat to our planet. Lucie Green finds out how ESA's Solar Orbiter will withstand the Sun's fierce glare and what the mission may discover.

*Check www.bbc.co.uk/skyatnight for subsequent repeat times

PERSEIDS SPECIAL

See the Perseids

Broadrake, Ingleton, 12 August, 10pm



The Perseids meteor shower is one of the most spectacular in the calendar. This year, Ingleton Stargazing Group is hosting an evening of meteor watching for adults and children alike, as part of the Overground Underground Festival. It's free to attend, but donations to the festival are welcome.

www.broadrake.co.uk/stars.html

Dark-sky meteor spotting

Scottish Dark Sky Observatory, Dalmellington, 13 August, 10pm



This observatory on the edge of Galloway Forest Dark Sky Park provides the perfect dark-sky conditions for spotting some Perseid meteors. A perfectly timed new Moon should add to

a successful evening of observing (weather permitting). This event is £16 for adults, £12 for those aged 65+ and £10 for children. Advance booking essential. scottishdarkskyobservatory.co.uk

Perseids and the planets

Durlston Country Park, Swanage, Dorset, 12 August, 9pm



Join Wessex Astronomical Society for a night observing Venus, Jupiter, Saturn, the Milky Way and summer constellations, along with a session of naked-eye meteor spotting. The evening will begin with an astronomy-

related talk, after which telescopes will be available and society members on hand to help spot some Perseids. The event is £3 for adults, £2 for children. www.wessex-astro.org.uk

MORE LISTINGS ONLINE

Visit our website at www.skyatnightmagazine.com/whats-on for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the web page.



A PASSION FOR SPACE



with **Dr Andrew Steele**

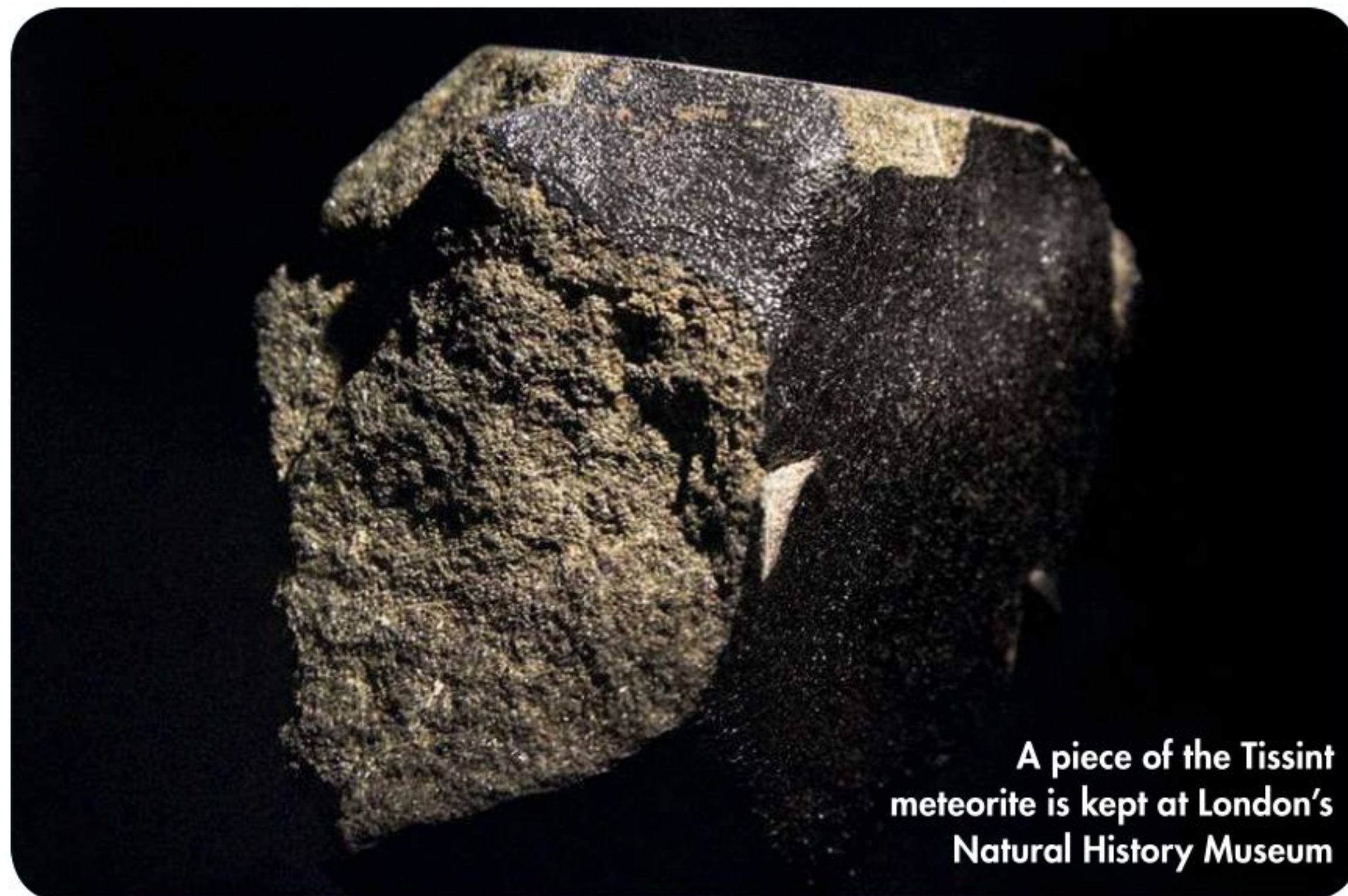
It's time to redefine what we mean by life, says one of the team who recently discovered organisms on Mars

Since the Viking missions of the 1970s and the excitement of the debate about life in the Martian meteorite ALH 84001, there has been a missing piece of the jigsaw when it comes to Mars: where are the organic carbon compounds? At the very least, Mars's surface has had carbonaceous meteorites hitting it for billions of years, but

other research on meteorites from Mars that have reached Earth has shown an indigenous organic carbon component. However, Mars meteorites on Earth lack the context of in-situ investigations.

Curiosity's SAM (Sample Analysis at Mars) instrument gave us intriguing hints in the form of small chlorinated organics (ie, chloromethane and derivatives) but more complex organic matter is elusive. Investigations into the Martian meteorite Tissint revealed an inventory of complex organic carbon, oxygen, sulphur, chlorine and nitrogen compounds that were indigenous to Mars. Tissint ultimately held the key to the search on Mars by SAM.

Analysis of Tissint by instruments similar to SAM on Earth showed us key analysis parameters to use in crunching the data acquired on Mars. Ultimately, the positive detection of complex organics was



A piece of the Tissint meteorite is kept at London's Natural History Museum

informed by extensive and exhaustive analysis on Earth – often the hidden aspect of many missions' science is this extensive effort to understand the mission data.

Life, but not as we know it

What does this detection mean in terms of our understanding of Mars and the potential for life? Ultimately in any search for life the difficulty resides in proving a robust detection of a potential life form that may or may not be there, and which might be very different from what we know as life on Earth. One way to combat this is to define a strategy with minimal assumptions on the nature of the life to be detected. Simply put, life is complex and may involve chemistry that concentrates specific organic compounds in a way that's different from organic chemistry. Carbonaceous meteorites and reactions

that led to the start of life on Earth contain an inventory of organic carbon from non-life or abiotic reactions. These represent a blank slate we can use to baseline our search for life.

The detection of methane and complex organics on Mars offers us that now. They are a background to pick apart in minute detail the composition, context and complexity of the organics present and relate them to specific

processes that could form them: meteorite infall to Mars; organic synthesis on Mars through abiotic reactions; or creation by a Martian life form. The search for life on Mars is a multidisciplinary journey executed on two planets by instruments that are the finest designed by our species.

It has taken nearly 50 years since Viking to advance our understanding of the organic carbon cycle on Mars to the point where we can ask these specific questions. Without doubt combining this discovery with future mission science that will begin the task of returning samples from Mars, this is the best and most exciting time to be a scientist looking for signs of life on Mars. **S**

DR ANDREW STEELE is senior staff scientist at the Carnegie Institute of Washington, whose work contributed to the detection of organics by Curiosity on Mars

JON CULSHAW'S



EX PLANET EXCURSIONS

In a trinary star system Jon visits a gas giant that looks strangely familiar



In this trip, I'm guiding my ship, The Perihelion, to the constellation of Centaurus. Our destination is a

fascinating trinary system called HD 131399, 320 lightyears away. So the light reaching Earth from this trio began its voyage when William and Mary jointly ruled England – our own history is a useful way of making such astronomical distances relatable.

The three stars of HD 131399 are gravitationally bound together, the brightest being HD 131399 A, a younger, white, A-type star twice the mass of the Sun. Stars B and C of this system are paired up like a double act, closely bound to each other at 10 AU. When stars are linked together like this, the numerous gravitational influences affecting the stars and planets around them become all the more intriguing to follow.

The planet we're visiting is the mighty HD 131399 Ab, a young, 16-million-year-

old gas giant orbiting the white, A-type star at 80 AU and thought to be four Jupiter masses. Settling the Perihelion on the surface of an Earth-sized moon orbiting the planet gives a staggering view of the trinary system. The moon's orbit around HD 131399 Ab means it's tidally locked with the parent planet, never altering position in this alien sky.

Spectroscopy has determined that the atmosphere of HD 131399 Ab contains copious amounts of water and methane. It's a colossal planet, resembling a hybrid of Titan and Earth; sandy beige and brick-red bands merge with swathes of Earth-like blue, grey and white.

As the surface of the alien moon we've landed on has an aluminium-grey, glacial quality, looking up to see such familiar shades of Earth on its parent planet brings to mind those iconic images of our home planet taken during the Apollo landings. From our vantage point, although the planet keeps the same position, the sky behind it visibly changes. It's compelling to observe the

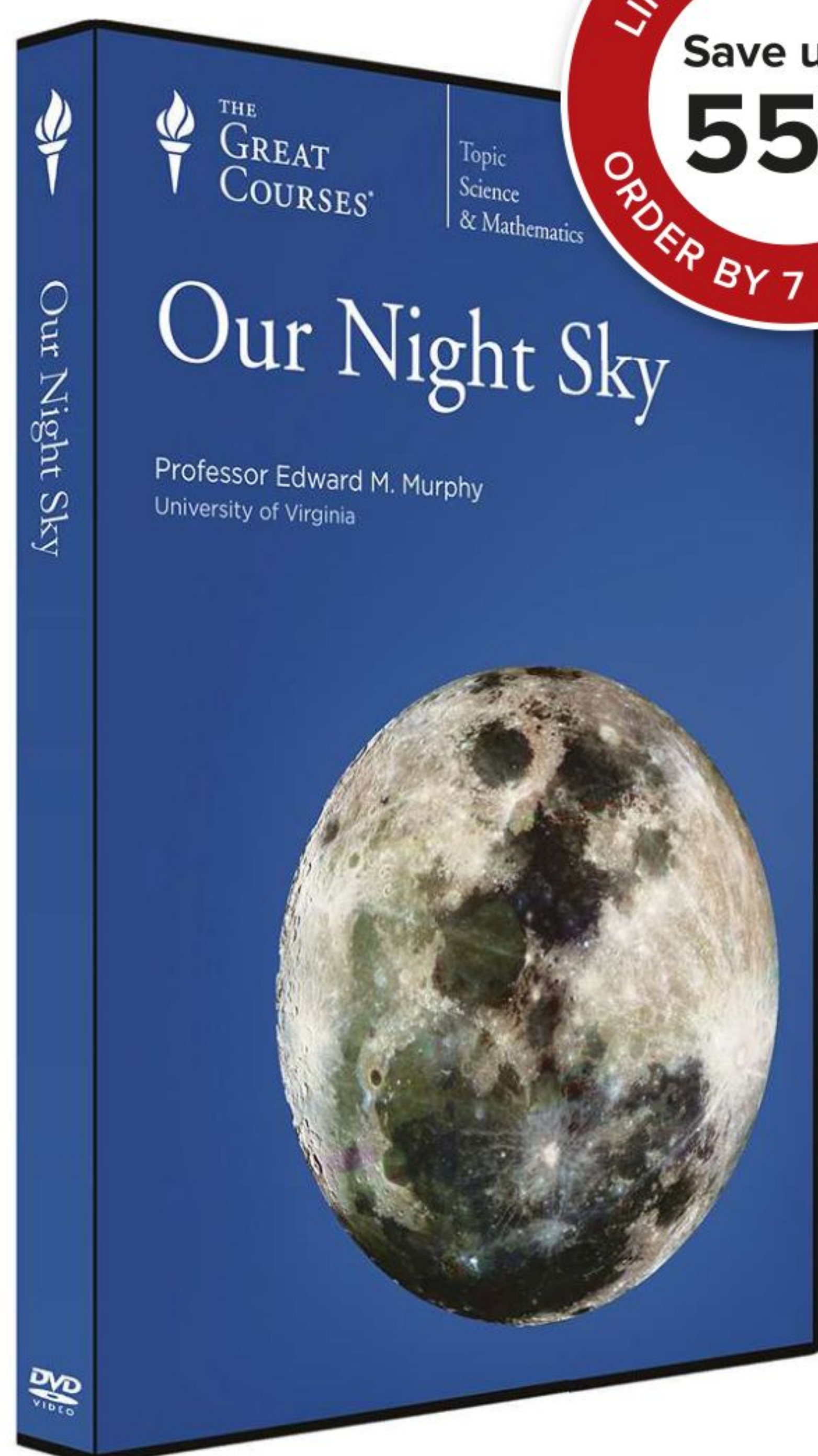
subtle movement of stars behind a bold, fixed and imposing gas giant.

It almost looks like a BBC TV globe ident of the far future. If ever the venerable Corporation decides to set up a BBC Centaurus service this view will provide the ideal logo. As I contemplate how many years we may be from galaxy-wide broadcasting, I reverse-launch the Perihelion to set out for our next journey.

The tidally locked nature of this moon makes for a desperately tricky escape from the formidable gravitational grip of this system. It feels as if my ship is tidally locked too. With a sickening jolt and a sound like an almighty sonic boom, the ship's antigravity drives kick in and I manage to just about free the ship. The Perihelion makes a juddering, hesitant escape from the system's gravity but the noises from the interdimensional propulsion regulators don't sound good. It'll need a service at Area 51 soon.

JON CULSHAW is an impressionist, comedian and guest on *The Sky at Night*





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MESSAGE
OF THE
MONTH



**This month's top prize:
four Philip's books**

PHILIP'S The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2018 Stargazing*.

Tales from THE EYEPIECE

Stories and strange tales from the world of amateur astronomy by Jonathan Powell

When Sir Patrick Moore first mentioned that the Infrared Astronomical Satellite had detected potentially planet-forming debris circling a handful of stars, I sat bolt upright! The search for extraterrestrial life is a passion of mine, even if only to answer to Fermi's famous question, "Where is everybody?" One of the stars discussed was Fomalhaut, which skims our southeast horizon. I had to see it for myself. One early morning as I walked up my garden path, I spotted a star nestled between two of my neighbours' houses. I was so fixed on the star, crouching and twisting my head to determine what it was, that I completely lost my footing and ended up sprawled over the front lawn. Thankfully no one saw me, except that star (and millions of others!)

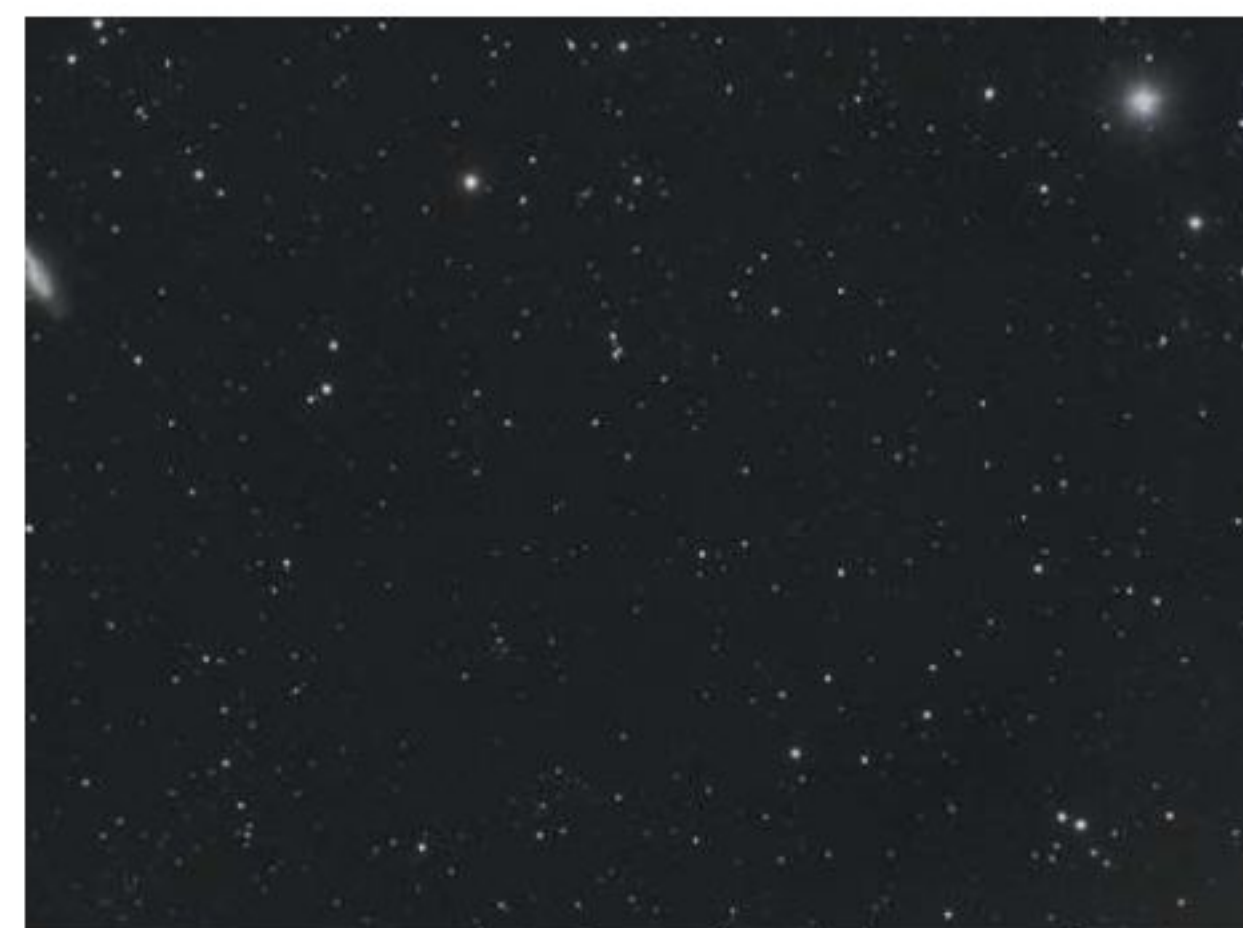
Email your own tales to Jon at TalesfromtheEyepiece@themoon.co.uk



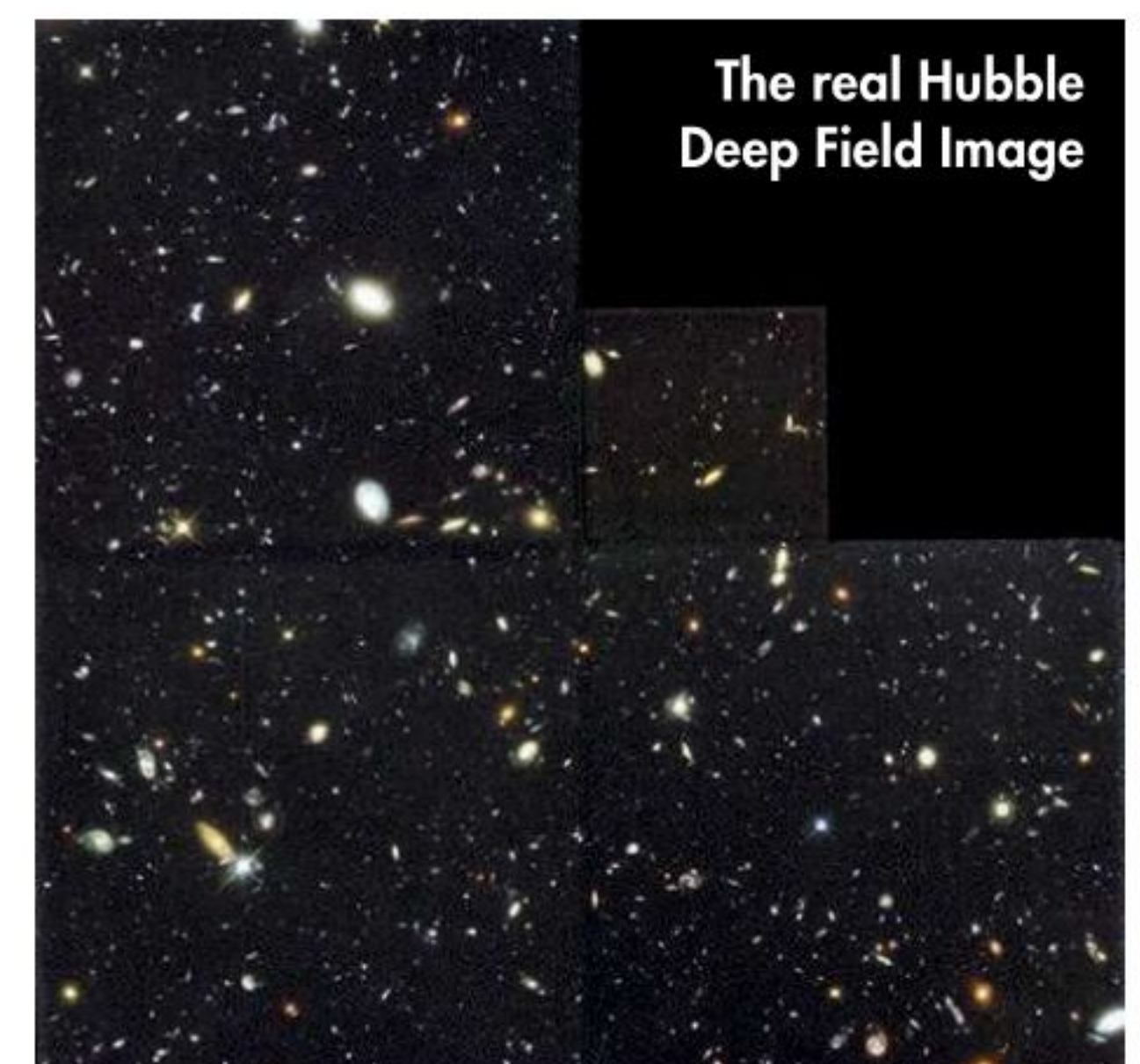
Jonathan Powell is the astronomy correspondent for the *South Wales Argus*

The Trouble with Hubble

Here is my quick attempt to capture the Hubble Deep Field image using my kit. I used a Sky-Watcher Equinox ED120 and an ASI1600 monochrome camera. The exposure of the images was 37x300s Luminance, 45x60s each for RGB. My scope was aimed and cropped to centre at RA 12h 38m 09s and Dec. +62° 13' 07". There's not much info showing up but plenty of fuzzies in the background. Any feedback would be welcome on what I have produced. Am I in the correct area and if



▲ Emulating the Hubble Deep Field image is tricky as it's such a minute portion of the sky



so, would stacking plenty more images bring out the galaxies in the Hubble image?
Alec Alden, Colchester

The Hubble Deep Field is centred on RA 12h 36m 49.4s, Dec. +62° 12' 58", and covers just 2.6 arcminutes to a side. It's such a small area that the slight difference in position means your field doesn't quite match up but you're not far off at all Alec! Give it another try. – Ed



▲ Bill Clutton's oil painting 'Another Small Step' celebrates the 1969 Moon landing

A lunar landscape

To celebrate the 60th anniversary of the Apollo space programme, my husband Bill painted this picture of Armstrong and Aldrin landing on the Moon in 1969. The

painting is entitled 'Another Small Step' and is oil on canvas. Bill is 71 and has been painting for most of his adult life; he has been interested in space and space travel since Sputnik. He has painted numerous space pictures mainly in oils and acrylics, a selection of which can be seen at the website of his local astronomy club, the South Cheshire Astronomical Society. Your magazine is very useful to him for composing quizzes for club nights when the weather's not suitable for observing.
Madaline Clutton, via email

That's a unique view of the Apollo 11 landing by Bill, Madaline. Glad to hear that the magazine is being put to good use at the local astronomy society! – Ed

Ice breaker

With Saturn low in the south at the moment, I am intrigued by its icy moon Enceladus. In November 2005 it was discovered that it emits huge plumes of ice from beneath its surface, some of which

falls back, but some keeps going and, in fact, makes up Saturn's E ring. Does this mean that Enceladus will one day disappear into Saturn's E-ring? And also, in the past was it much bigger before it started forming the ring? Is it possible Saturn's rings were formed by similar moons that are no longer in existence?

Derek Summers, Cardiff

The short answer is yes, Derek, Enceladus will one day vent its whole mass, but because so small a fraction of the material from its plumes ends up in the E-ring it would take about nine billion years, twice the current age of the Solar System. As most of the plume material falls back, the moon doesn't lose an appreciable size to the process. – Ed

Teatime with Venus

While enjoying a beautiful 1 July, at about 4.30pm I noticed a bright point of light approximately south in the sky about 50° from the horizon. I assumed it was an aeroplane, but after watching for a while I realised it was not moving. Consulting July's magazine for clues, I wondered if it was Venus or Jupiter, or was this wishful thinking?

Kevin Robotham, East Leake, Nottingham

You must have keen eyes, Kevin: Venus was at that altitude and in that direction on 1 July. Its brightness then, at around mag. -4.0, does make it visible as well. A great daytime spot! – Ed

Meanwhile on FACEBOOK...

WE ASKED: Are you planning on viewing the 27 July lunar eclipse?

Mark Shepherd

I'm a member of the Norwich Astronomical Society and a few of us, as well as friends and family, will be observing the Moon as it rises in totality over the North Sea.

Jon Sales

Probably be cloudy :-D

Sandra Grace

We at North Wales Astronomy Society are having an extra get-together for observing the eclipse so fingers crossed for clear skies.

Amanda Large

The eclipse happens on my birthday so I will raise a glass of red in its honour.

Izzy Bee

A clear sky would be special!

Jason Jardine

I'm expecting to see exactly nothing as the UK is bathed in cloud.

Tweets



John Pahl

@john_pahl • Jun 24

Iridium flare over the Eiffel Tower, Paris, Thursday last week
#catchtheirdium #iridiumflares
#flarewell @IridiumComm
@skyatnightmag
@catchtheirdium #Iridium14



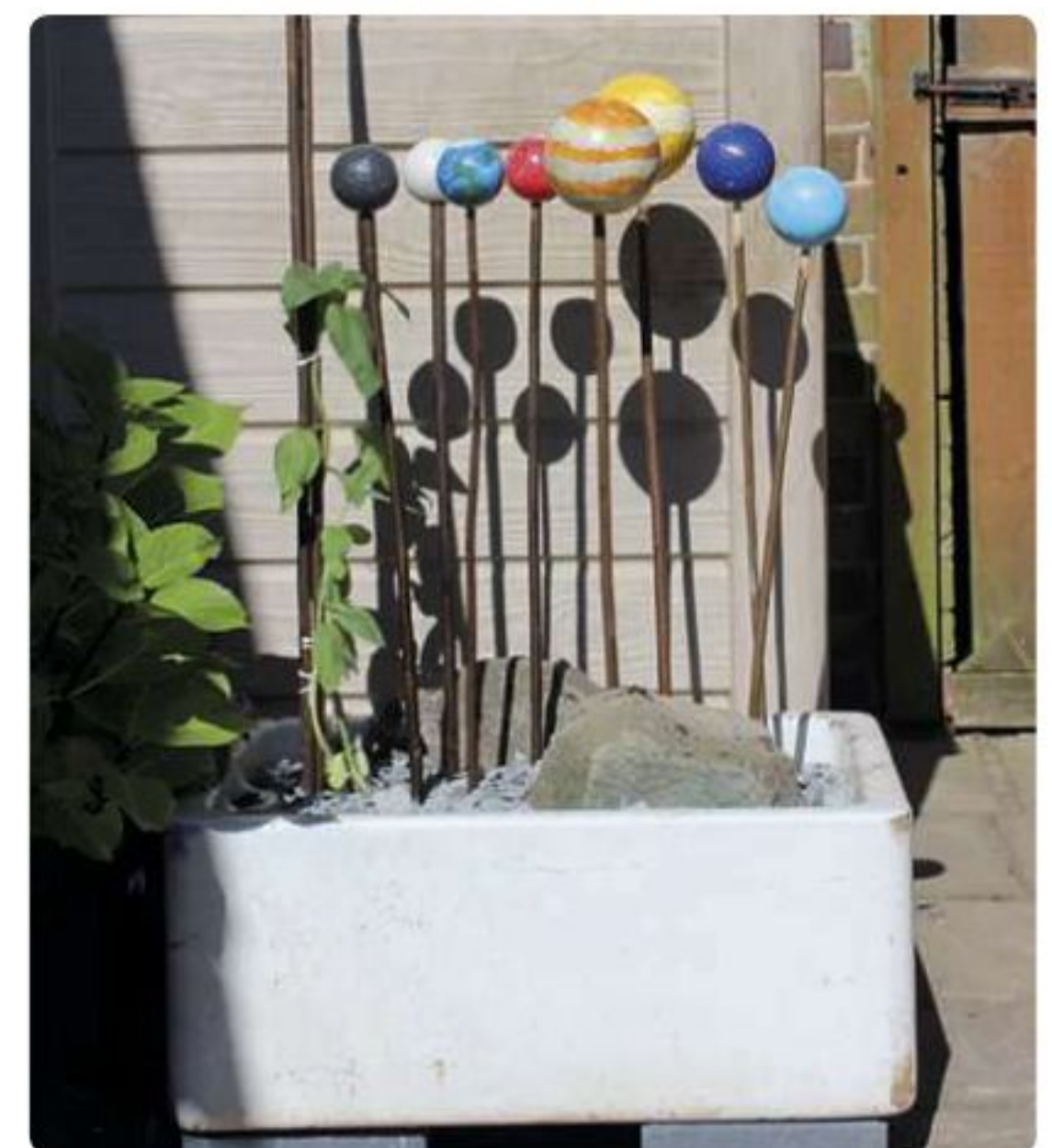
Tweets



Steve

@aboveeg • Jun 24

Behold!! The Solar System sink garden. Just need the Sun to now grow (and it might turn out to be a multiple system) @mockford_julie @jrussell46 @astro_niks @andy_stones @skyatnightmag @GWmag @DavidBflower #gardening #lovegardening #SolarSystem #planets #Sunflower #Sun



SOCIETY in focus



Members of Cardiff Astronomical Society attended Professor Barry Barish's talk at the National Museum Cardiff on 29 May. Barish is a

leading expert

on gravitational waves and was awarded the Nobel Prize in Physics in 2017 for his work on the Laser Interferometer Gravitational Wave Observatory (LIGO) alongside Rainer Weiss and Kip Thorne.

During his talk, Professor Barish took the audience on a whirlwind tour from the first proposal of gravitational waves by Henri Poincaré in 1905, to the first detection of gravitational waves at LIGO, produced from a pair of merging black holes around

1.3 billion years ago. As you can imagine, his talk raised all sorts of questions, such as where do gravitational waves go once they've reached Earth, and what does the future hold for gravitational wave research?

Barish is an inspiring and engaging speaker. His talk certainly made us feel we'd learnt and understood what gravitational waves are and their importance in our understanding of the Universe.

Cardiff Astronomical Society was founded in 1975 and is one of the biggest societies in the UK with over 300 members. It meets fortnightly at Cardiff University to listen to lectures from various speakers from all over the country, and has an observatory at Dyffryn Gardens on the outskirts of Cardiff where regular observing sessions are held.

Katrin Raynor-Evans, CAS librarian

Find out more about the society at www.cardiff-astronomical-society.co.uk

OOPS!

In July's issue, Society in Focus incorrectly stated that the maximum number of visitors to Hampshire Astronomical Group's site in the South Downs Dark Sky Reserve is four. The capacity of the site is in fact 40.

BBC

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Hotshots

This month's pick of your very best astrophotos

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CONTENT**

A gallery
containing these
and more of your
stunning images



▲ Centaurus A

FERNANDO OLIVEIRA DE MENEZES, SÃO PAULO, BRAZIL, 18 MAY 2018



Fernando says: "I took this image at a meeting of astrophotographers in Saltão. Centaurus A has always fascinated me and I always

wanted to photograph it. When I saw the first image I captured, I was very excited by the immense amount of small galaxies in the image, and I called my fellow astrophotographers over to have a look."

Equipment: QHY16200A monochrome CCD camera, Sky-Watcher Esprit 150 ED triplet refractor. **Exposure:** 60x300". **Software:** PixInsight, Photoshop.

BBC Sky at Night Magazine says: "Fernando's image is full of impressive detail and is incredibly crisp. We love that he's so clearly captured the stellar glow and the dark band of gas and dust blotting out starlight."

About Fernando: "I got into astrophotography about five years ago. I started out because I bought an apartment and then I purchased a telescope to go with it! When the scope arrived I was utterly fascinated, and from then I started to read books on astronomy and take it out during clear nights. I do astrophotography for the feeling of forgetting the world around me and contemplating the beauty of the Universe."



◀ The Milky Way

KRIS WILLIAMS, CADAIR IDRIS, SNOWDONIA, 21 APRIL 2018



Kris says: "I hiked up to the summit of Cadair Idris for some landscape photography and to wild-camp there for the night, given that the weather forecast

was clear. I've often wished to be able capture the galactic core of the Milky Way as it rises from the horizon in the early summer months behind that scene. I waited until as late as possible to take the image before the dawn twilight would interfere, so that the Milky Way could rise as high as possible."

Equipment: Sony α 7S camera, Batis 18mm f/2.8 lens. **Exposure:** ISO 6400, 20".

Software: Photoshop, Camera Raw.

The Pinwheel Galaxy ▶

GARY OPITZ, NEW YORK, US, 20-22 APRIL 2018



Gary says: "I chose to shoot M101 because I think it is photographically one of the most beautiful galaxies to image. And it is close and bright, which also makes it easier to shoot. April is also when it is in prime position in the sky, nearly overhead for the early part of night."

Equipment: ZWO ASI1600 MM camera, TEC APO140 f/7 refractor, Orion Atlas EQ-G mount. **Exposure:** 60x120" luminosity, 35x180" each RGB. **Software:** PixInsight, Photoshop.



◀ The Sun

STEVE HELICZER, HERTFORDSHIRE, 7 MAY 2018



Steve says: "I capture using a monochrome camera; around 80fps in FireCapture. I ensure the histogram is full and the gamma is turned up to around 60, which improves the contrast. All my exposures are around 70 seconds."

Equipment: ASI ZWO 120MM USB 3.0 mono camera, Tecnosky 100mm f/5.8 quadruplet apo refractor, Celestron Advanced VX mount.

Exposure: 2x80x70" proms, 3x80x70" disc. **Software:** AutoStakkert! 3.0, RegiStax, PaintShop Pro.



▲ The Orion Nebula

TOM HARBIN, ESSEX, 16 NOVEMBER 2017



Tom says: "I wondered why so many people went on about the Orion Nebula and how it's a great rookie target. It was a cold November morning when

I found out why. A pleasure to shoot. There's tons of room for improvement, but I was very pleased with this early attempt of mine."

Equipment: Canon Rebel T5i DSLR camera, Celestron NexStar 127SLT computerised Maksutov-Cassegrain, altaz Go-To mount.

Exposure: ISO 12800, 56x10' lights, 29x10' darks, 76x1/4000" bias, 22x20' lights detail.

Software: DeepSkyStacker, Photoshop.

The Iris Nebula ►

JAY BOLT, WEST YORKSHIRE, 5-6 MAY 2018



Jay says: "The Iris Nebula is a challenging target for imagers looking to bring out the dark dust lanes that surround it. To try to best capture the dust, I elected to shoot longer sub-frames over two nights."

Equipment: QHY163M mono CMOS camera, Sky-Watcher Explorer 130P-DS OTA Newtonian, Sky-Watcher EQ6-R Pro mount.

Exposure: 6.2h L, 1h each RGB. **Software:** Astro Pixel Processor, PixInsight.





◀ Star trails

PETER LONGDEN, BUCKINGHAMSHIRE,
13 MAY 2018



Peter says: "This was my first attempt at capturing star trails with a tripod-mounted DSLR. I'm pleased with how it turned out."

Equipment: Canon EOS DSLR camera, Manfrotto MK190XPRO4 tripod, Sigma 24mm f/1.4 DG HSM Art lens. **Exposure:** ISO 6400, 40x30".

Software: Canon Digital Photo Professional, Photoshop CC.

▼ The Milky Way

MARK PELLEYMOUNTER, KIMMERIDGE BAY,
DORSET, 20 MAY 2018



Mark says: "A mist cleared just as the Milky Way aligned with the tower and the headland."

Equipment: Canon EOS 5D Mark III DSLR camera, Canon 24-105 f/4 lens, Sky-Watcher Star Adventurer. **Exposure:** ISO 1600, 7' sky, 11' foreground. **Software:** Photoshop.



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We've teamed up with Altair Astro UK to offer the winner of next month's Hotshots an Altair Astro Premium 1.25-inch CLS-CCD Filter with UV/IR Block & AR Coating, designed to reduce the effects of light pollution and skyglow for DSLR, CCD or CMOS cameras – www.altairastro.com • 01263 731505

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The Moon at maximum totality
as seen from France during
the last total lunar eclipse
on 28 September 2015

RISE of the red MOON

A lunar eclipse and Mars at opposition will make for a fantastic celestial sight towards the end of July.

Paul Money reveals how best to see it

Eclipses are amazing spectacles to behold and worth looking out for. None more so that the lunar eclipse on 27 July, when we'll witness not just the deep red Moon that's so distinctive of a lunar eclipse, but also Mars, the Red Planet, rising nearby and shining at its brightest for 15 years.

On that last Friday in July, the Moon will already be eclipsed as it rises. This in itself will make the event very interesting, as the thicker atmosphere towards the horizon will dim and redden the already eclipsed Moon. The Moon will also rise through the dark band of Earth's shadow projected onto the atmosphere, the Belt of Venus, so you may need a keen eye to spot it very close to the horizon.

Moonrise will occur at approximately 21:10 BST (timings will vary slightly around the UK) over in the southeast; by then the initial penumbral phase of the lunar eclipse will already have happened so the Moon will have entered into totality and taken on a red hue before it becomes visible. Make sure you have a clear, unobstructed view of the horizon in the direction of moonrise if you want to be in with a chance of catching the peak of totality, which will occur shortly afterwards at 21:22 BST.

As the blood red Moon continues to climb higher, there's the added bonus of Mars rising around 20 minutes later, close to 22:00 BST. The Red Planet will be lying just below and to the right of the totally eclipsed Moon, creating a gorgeous spectacle. ►

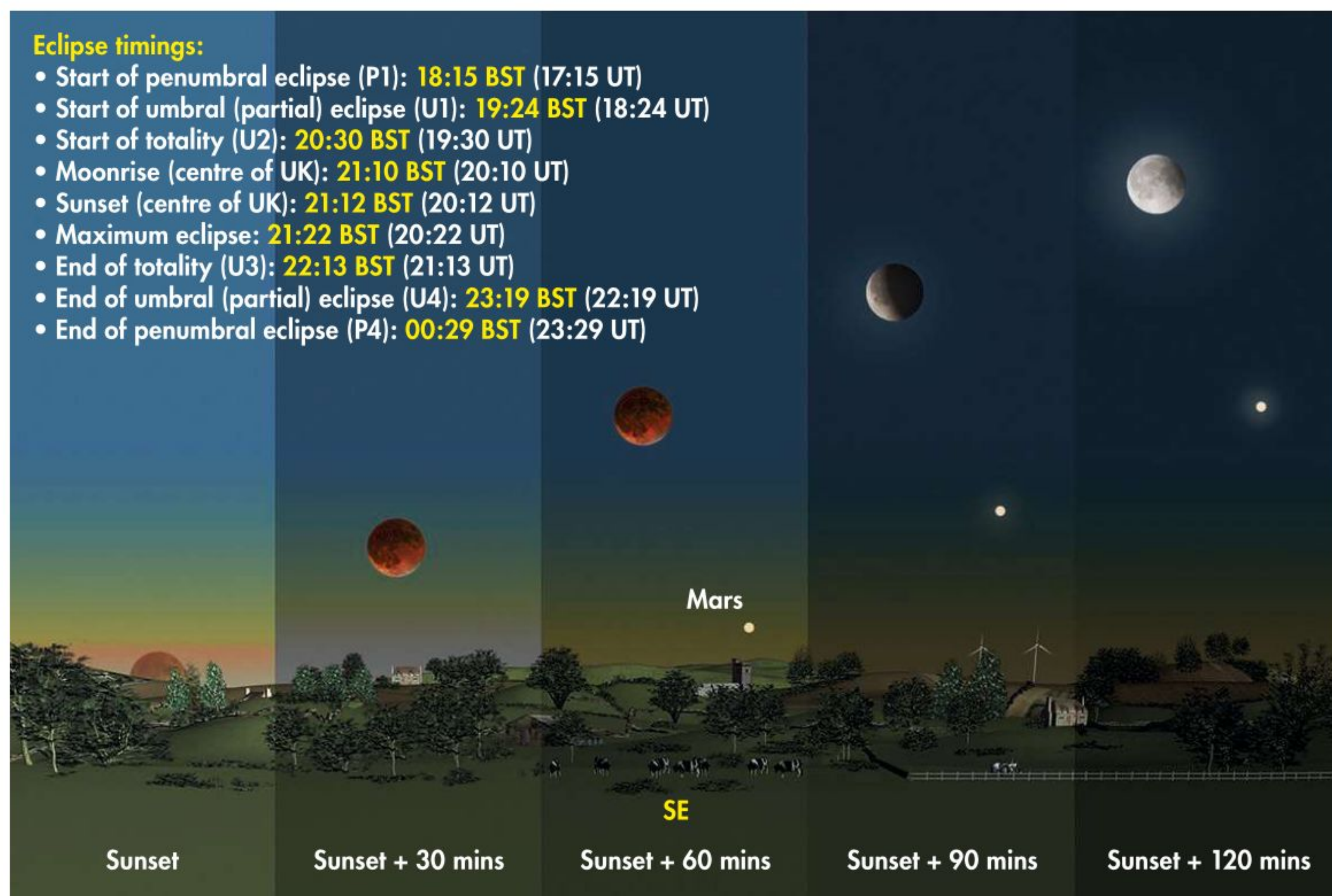


ABOUT THE WRITER

Paul Money is a writer, broadcaster and reviews editor for *BBC Sky at Night* plus a passionate proselytiser for all things astronomy

Eclipse timings:

- Start of penumbral eclipse (P1): **18:15 BST** (17:15 UT)
- Start of umbral (partial) eclipse (U1): **19:24 BST** (18:24 UT)
- Start of totality (U2): **20:30 BST** (19:30 UT)
- Moonrise (centre of UK): **21:10 BST** (20:10 UT)
- Sunset (centre of UK): **21:12 BST** (20:12 UT)
- Maximum eclipse: **21:22 BST** (20:22 UT)
- End of totality (U3): **22:13 BST** (21:13 UT)
- End of umbral (partial) eclipse (U4): **23:19 BST** (22:19 UT)
- End of penumbral eclipse (P4): **00:29 BST** (23:29 UT)



◀ A visual guide to what you can expect to see in the evening of 27 July this year, so long as the weather decides not to spoil the fun

► Mars is practically at opposition during the lunar eclipse and consequently will be easy to make out. The planet actually reaches its biggest and brightest on the morning of 27 July, shining at around mag. -2.8 , which is as bright as we've seen it since 2003 – another bonus of this combined spectacle. With a disc size of just over 24 arcseconds, the Red Planet will be at its closest to Earth just three days later on 30 July.

More sights to see

But late in the evening on 27 July the Moon and Mars will be separated from each other by a little over 6° (that's about three finger widths held out at arm's length), so they may just fit in the view of

“Take advantage of the sociable hour and the fact that both are safe to view with the naked eye, binoculars or a telescope”

a pair of binoculars. Catch them quickly together: totality ends at 22:13 BST.

As the Moon comes out of totality it loses its red hue. Now comes the umbral or partial lunar eclipse, which looks almost like the phases of the Moon in

▼ The lunar eclipse of 15 April 2014 (the first of two that year) with Mars visible to the far right



Mars →

Capturing THE ECLIPSE

How to image the Red Planet and red Moon together

On the 15th, Mars rises at 21:55 BST and when the Moon comes out of eclipse you'll have to compose and capture your images before the end of totality at 22:13 BST. Use a camera on a tripod with manual settings and attach a 50-70mm lens to get both the Moon and the Red Planet close in your field of view. Or alternatively use a wide lens such as an 18mm to capture lots of stars around the two bodies. If you're not using a tracking mount, then for the 50-70mm lens you should use a reasonably high ISO setting of 1,600 or higher to keep the exposure time down to five seconds. This will help you avoid star trailing but if you're feeling confident, it doesn't hurt to experiment. Wide-field lenses can take longer exposures of up to 20 seconds before trailing will start to occur. If you use a tracking mount then longer exposures can be achieved, but bear in mind that with a wide field lens you may also have horizon objects in the view and they'll appear blurred as the mount tracks the apparent movement of the sky.



A camera with a 50-70mm lens on a fixed tripod is a perfect setup for capturing this crimson combo



▲ At totality, the Moon doesn't vanish in shadow, but takes on a crimson hue instead, thanks to Earth's atmosphere refracting the Sun's red light



▲ The Moon rising over Canada in partial eclipse for what would eventually be the total lunar eclipse of 27/28 September 2015

reverse. It becomes silvery white in colour and a distinct 'terminator' line is visible, separating the part of it in Earth's dark shadow.

The Moon then leaves the umbra – the darkest part of the shadow – at 23:19 BST and enters the penumbral phase, which is quite subtle and not as easy to see. By then the Moon will be over in the south-southeast, where eventually the eclipse ends at 00:29 BST, with Mars still lying close below.

Throughout the visible part of the eclipse, you should also be able to see the bright stars Alpha (α)

and Beta (β) Capricorni just above the Moon. These lovely double stars are ideal for viewing through binoculars and will add even more to the spectacle.

So why will the Moon rise a red colour on the 27th? It's all to do with where the Earth, the Moon and the Sun are in relation to each other. At a lunar eclipse the Moon lies in the opposite part of the sky to the Sun. As Earth is between them, sunlight passes through Earth's atmosphere and gets refracted so that we see the red portion of the spectrum reflected off the Moon during totality.

Of course, this particular alignment of Sun-Earth-Moon is what happens at every full Moon. But we don't see a lunar eclipse once a month because the Moon's orbit is inclined by 5° relative to Earth's orbit. So most months the path of the Moon's orbit takes it above or below the shadow cast by Earth into space and we see a normal, silvery, bright full Moon.

Having said that, lunar eclipses do happen more frequently than solar eclipses: in any given year there can be up to a maximum of three. Indeed, the next total lunar eclipse we'll get to see in the UK will be on 21 January 2019, when proceedings begin at 02:30 UT.

The 27 July lunar eclipse promises the magic of a close pairing with Mars, so take advantage of the sociable hour and the fact that they're totally safe to view with the naked eye, binoculars or through a telescope – this is one celestial event not to miss. **S**

The complete guide to METEOR OBSERVING



ABOUT THE WRITER

Dr Elizabeth Pearson is *BBC Sky at Night Magazine's* news editor. She gained her PhD in galactic astronomy at Cardiff University

Ahead of a favourable Perseids, **Elizabeth Pearson** looks at the many ways you can observe meteors

Meteor showers are a majestic event to witness – you scour the night sky waiting to see the flash of light as a piece of space debris meets its end in our atmosphere. For many people, watching a meteor shower is their first foray into astronomy, and when the Perseids peak in mid-August there will be many people heading out to watch them.

With little moonlight to battle against, this year's shower promises to be a great show for

casual observers. But for the more advanced astronomer, the shower offers a chance to do more than just look up and go, "Wow!" There are a number of advanced techniques that add an extra level of interest to the experience, and which bring a whole new set of challenges.

In this feature, we'll look at some of the different ways you can start not just watching, but studying meteors. No matter what your skill level or preferred method of observation, there's a way you can become more involved. ▶

Once we called them shooting stars.
Now we know they're disintegrating
space debris. But meteors remain one of
the sky's most crowd-pleasing displays

You can help the BAA keep its data up to date for visual meteor sightings

Visual observations

All you need to study meteors are a deckchair, a notebook and your eyes, says the BAA's **John Mason**



"A lot of people visually observe meteors but don't collect any data, which is a shame. All you need is a chair from which you can comfortably view the sky and something to record your information with, either a notebook or voice recorder. It

doesn't matter what direction you look, but note it down. Also record what the sky's like: how clear it is in terms of cloud and what the limiting magnitude is [see the Jargon Buster on page 39]. Then write down what time you started observing and your time zone to avoid later confusion.

"Then just watch. When you see a meteor, note the time it appeared and what kind of meteor it was. Was it from a shower or a sporadic meteor? You can work that out by tracking the path of the meteor back and seeing if it came from the shower radiant – if it didn't, it's sporadic.

"If you want to be a bit more sophisticated you could attempt to measure the brightness of the meteors by comparing them with nearby stars, but that's a skill that takes some practice to perfect. Finally, you might want to note if you saw any persistent trains and how long they lasted. The Perseids are rich in persistent trains.

"Observe for at least 30 minutes, better yet an hour. Then have a break and start again. Note the start and end times for all your sessions during the night, making sure it's clear what the date is when it changes at midnight. You can also work as part of a group. Set yourselves up so that you're all



covering a different section of sky and record your observations as individuals.

"The next day, write up a clear report of your observations and send it into the BAA. We can then use your data to see the changing rates of meteors observed during the night caused by the structure within the dust stream of the Perseid meteoroids.

"Most people will monitor the meteor showers, but it's great when people observe at other times. Then we can learn about meteor activity at other times of the year. It's also really helpful when people go out a few nights before and after the peak of a shower.

"You might say, 'In this day and age of video cameras and DSLRs why do we still need visual observers?' Well, we've had visual observations for over 100 years. And the only way you can compare like with like is for people to go out and do the same thing as we've always done."

www.britastro.org

JOHN MASON is director of the British Astronomical Association's visual meteor observation section

▲ John Mason and Chris Lintott discussed meteors on *The Sky at Night* in 2005 before a successful group observing session

Finding micrometeorites

Meteorites can be found almost anywhere, if you know how to look

Many meteor hunters share one dream – making an observation that will lead to the discovery of a meteorite. By tracing the path of a bright meteor, you can work out where to look for any surviving meteorite fragments. Some meteorites have been found like this in flat and uniform places, such as Australia or the Arctic. In the UK, which is neither flat nor uniform, the task isn't so easy.

However, there is a way to search for meteorites without trudging through the British wilderness. Every day, 60 tonnes of cosmic dust falls to Earth, including tiny metallic particles known as micrometeorites. Over the last decade over 500 micrometeorites have been found on roofs and sifted out of gutters as part of Project Stardust, led by Jon Larson.

All you need to join in the search is a magnet strong enough to attract any micrometeorites. Wrap the magnet tightly in plastic to avoid them sticking to the actual magnet, then wrap both in a second bag in case the first tears.

The best place to search for micrometeorites is a roof. Sweep your chosen roof with the bagged magnet, taking particular care in places where rainwater run-off makes dirt gather, such as gutters. After a while you should find that your plastic bag is covered in material.

Next you need to remove the dirt you've collected from the magnet. Hold the magnet over another clean and labelled plastic bag. Carefully take the outer bag off the magnet, so that the material falls off the magnet and into the labelled bag.

Next comes the sorting. Sift the material you collected first through a coarse sieve (with around



1.5mm holes), then a fine one (0.4mm holes). Now place any remaining particles in the second sieve in a shallow dish and rinse with water and perhaps some dish soap. Scoop out what's left at the bottom of your dish and look at it under a microscope.

If you're patient, and lucky, you may find some tiny metallic spheres. These are your candidate micrometeorites. The only way to be sure that's what they are is to send them to a meteorite testing and classifying institution. In the UK, either the Natural History Museum or the Open University, will be able to give further advice. ►

▲ Double-bagging a magnet makes removing small metallic particles from the magnet a whole lot easier. Some of them might be micrometeorites. Guttering is a good place to hunt for micrometeorites with your bagged magnets

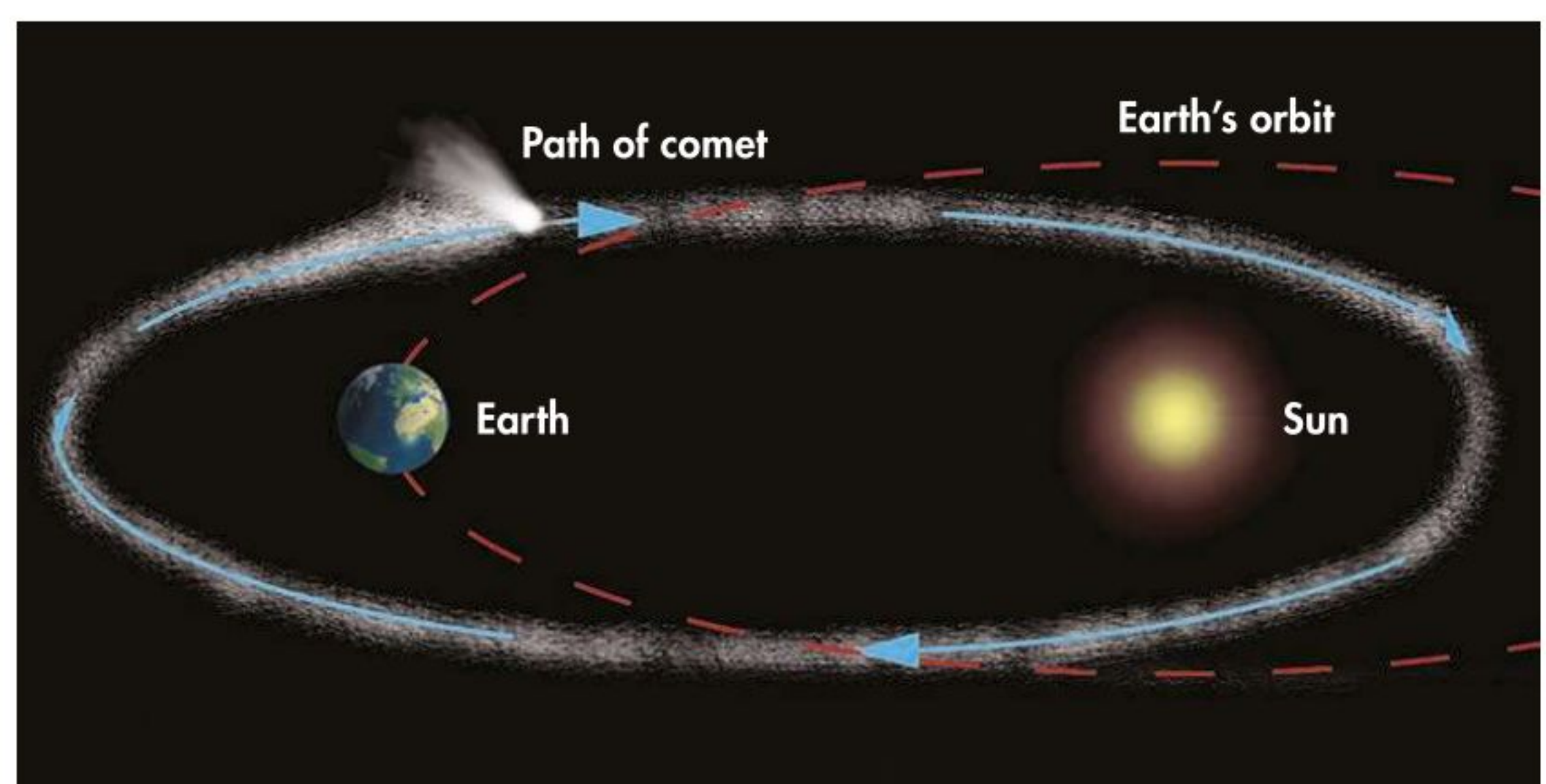
WHAT CAUSES A METEOR SHOWER?

Meteor showers are born from the remnants of comets

When a comet travels close to the Sun, it begins to melt and form the spectacular tails that can be seen from Earth. However, the gas and dust in these tails is left behind once the comet passes, creating a stream of particles in orbit around the Sun.

Earth's orbit crosses some of these streams and when it does the particles strike the atmosphere at a speed great enough for the air around the meteoroid to superheat and start to glow. This bright light streaking across the sky is what we know as a meteor.

However, the heat causes the outer layers of the meteoroid to ablate, or burn up, and often by the time the friction of the air has slowed the space rock down, there's nothing left of the meteoroid except dust. Only with larger examples does part of the meteoroid survive and impact on the surface of our planet as a meteorite.



▲ We witness meteors when Earth passes through a trail left by a comet

Automatic camera monitoring

How your home could become part of a nationwide meteor detection network

Setting up a camera at home means that you can record meteors all night, every night.

"To get started you need a CCTV camera with an auto iris lens, which will automatically protect the camera from the sunlight during the day," says Peter Campbell-Burns, one of the founders of the UK Meteor Observing Network (UKMON), a group of amateur astronomers who run their own meteor detection cameras.

"The cameras need to sit inside a waterproof housing so that you can set them up outside. You need a video decoder, which turns the analogue camera signal into a digital form and passes it to a PC. Then we use the UFO software suite from SonataCo to run the cameras, and record and analyse data. Alternatively you can use CAMS. Depending on what you can scrounge, the cost of setup is a few hundred pounds."

Once you have all the equipment, you will need to find the best place to set up your camera. Provided they aren't pointed directly at a bright light, most cameras can handle modest light pollution. However, if you really want to maximise the potential usefulness of your observations you may want to consider joining a meteor observation network, such as UKMON.

"The real beauty of what we do is that we combine data from various cameras. That's when things get exciting as we can use the two viewing points to triangulate the meteor's position and velocity. For most people, UKMON can find some direction in which their camera's field of view overlaps with another person's so we can match observations," says Campbell-Burns.

Once you're set up, all you have to do is wait for a clear night and set the software on your PC running.

"The software records any movement the CCTV camera picks up. It does pick up aircraft passing by and the occasional satellite, but hopefully you'll get a lot of meteors as well. It records a 10-second clip with the meteor moving through the field of view," says Campbell-Burns. "Then you have to go

► A Perseid (top) and a Sigma Hydrid meteor (bottom) captured by two of the cameras in UKMON's network



through and process it with software such as UFO Analyzer. This calibrates the image using star positions so that it can calculate a meteor's trajectory."

With several observations of the same meteor from different locations it's possible to work out many details about a meteoroid, such as its original orbit or its speed when it hit the atmosphere.

"But people can get involved at whatever level they want to," says Campbell-Burns. "We've got some members who want to get involved with writing papers, and others who are interested in recording meteors."

www.ukmeteornetwork.co.uk

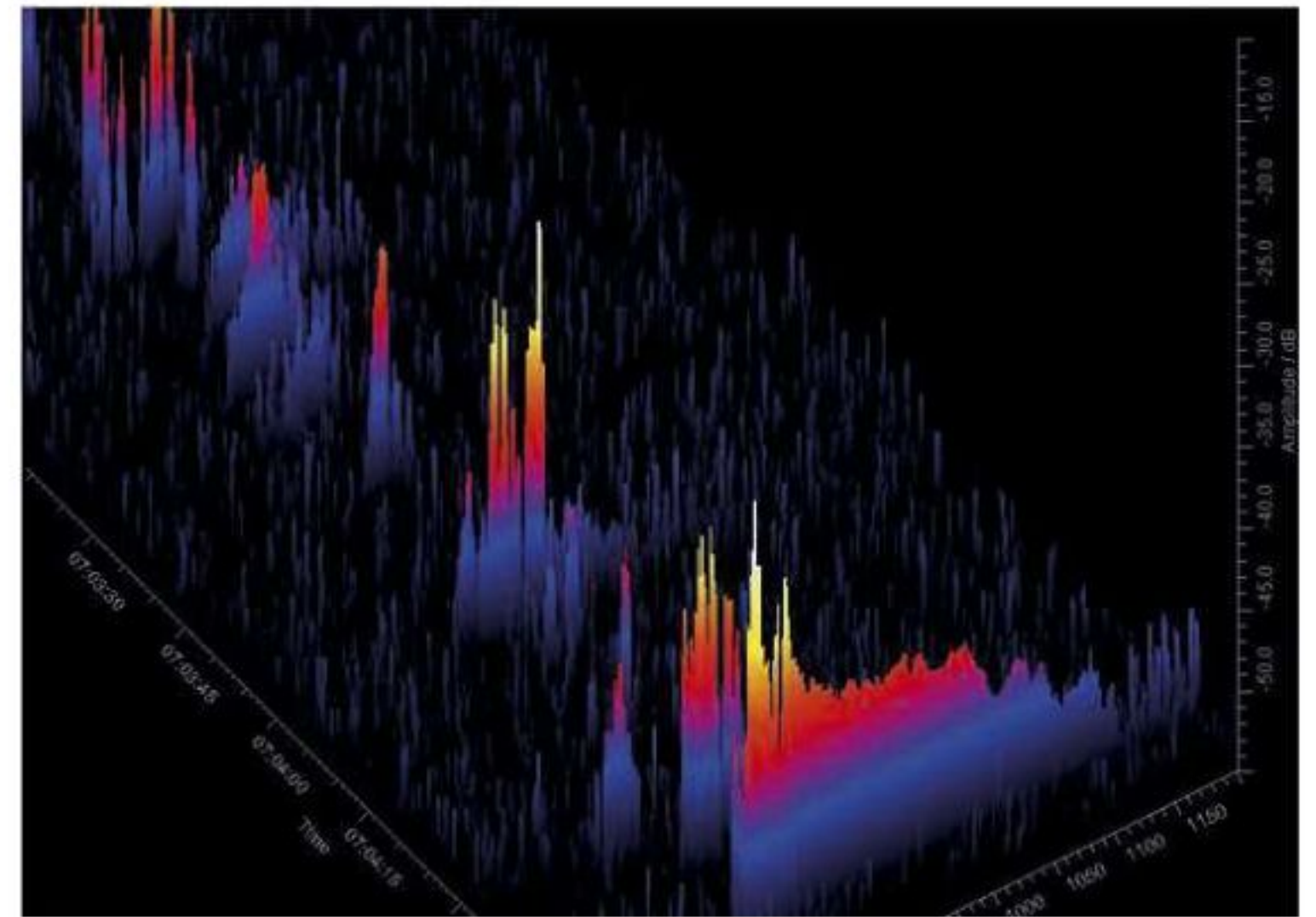


▲ A UKMON CCTV camera ready for action as soon as night falls. Inset: The camera has an auto-iris lens to protect it from sunlight during the day

► During a meteor shower the colourful blobs of a meteor detection can appear every few seconds

Radar observations

With this method it's possible to record meteors even when it's cloudy



Most meteors can only be observed on a clear night, but you can view meteors no matter the time or weather using radio waves. All around the world, stations are broadcasting radio waves into the upper atmosphere to track the flight of spacecraft. When the radio waves hit a satellite, they bounce back and can be detected here on the ground. However, these signals also bounce off the plasma trails left behind by meteors travelling through Earth's atmosphere, enabling anyone with the right equipment to use it as a meteor detector

"All you need is an antenna, a radio and a computer," says Dave Jones, a member of the Norman Lockyer Observatory. Before you set anything up, however, you need to identify your nearest broadcasting station. For UK observers, that will be the GRAVES station near Dijon, France.

"Point your antenna towards south-southeast to pick up GRAVES, though it doesn't need to be exact, especially if you have a wide-angle antenna," says Jones. "Put it as high up as you can get it safely and without causing any other problems, but at minimum a few metres off the ground. The antenna should be made for the 2m amateur band and directional antennae work much better."

Once you have a way of picking up the signal, you'll need a radio to detect it. "The radios must

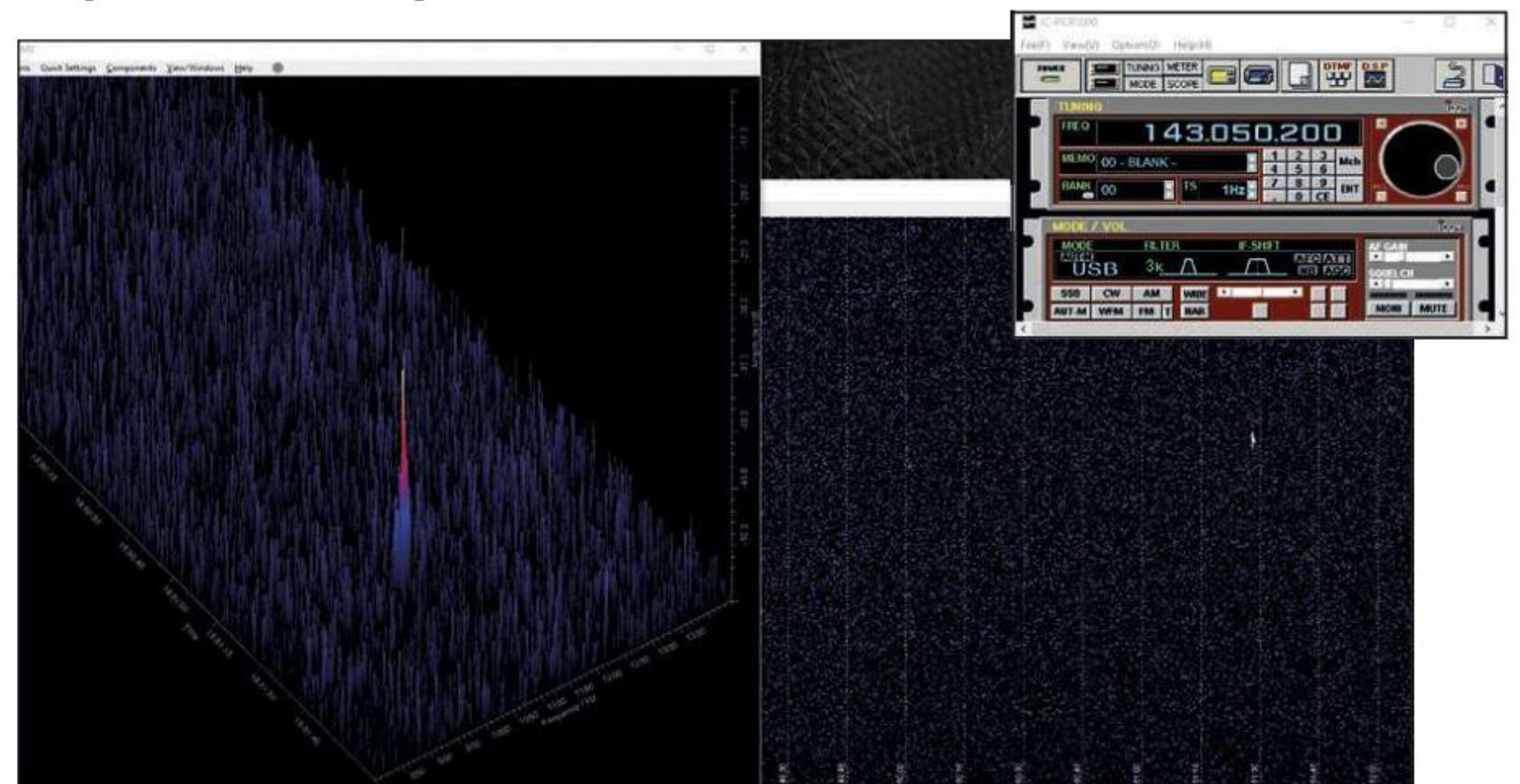
be capable of selecting upper side band (USB). AM/FM radios will not work," says Jones. "The FUNcube Dongle radio receiver works great. Or there's the IC-706MKIIG amateur radio transceiver, which is excellent, but a bit over the top for what's required here. For GRAVES they need to be tuned to approximately 143.049.800Mhz in the upper side band. It might take a bit of hunting to find the exact frequency. I'd suggest waiting until a meteor shower where there are more detections to help you."

After the radio is tuned, you should feed its output into your computer. This may require some additional software, so check your particular model's needs.

"Finally, you need software that shows you the detections on the screen. We use the free Spectrum Lab. But there is also SpectraVue or you can use RMOB Survey to count meteors, which you can then submit to rmob.org."

The radar bounce signals will now appear on your screen as colourful blobs. If you see one that only lasts a short amount of time, and isn't very even then congratulations, you have detected a meteor. But these are likely only from something the size of a grain of sand. Larger meteors, those that might be visible in the night sky, might last several seconds. **S**

<http://normanlockyer.com>



▲ Main image: Spectrum Lab software. Inset: Radio (PC software)

JARGON BUSTER

Radiant The point in the sky from which meteor showers appear to emanate.

Sporadic Meteors that are not associated with a specific shower or debris stream.

Limiting magnitude A measure of sky darkness; the dimmest magnitude star you can see from your location.

Trains Fast-moving meteors, such as the Perseids, can leave a vapour trail on the sky after they disappear.

Meteoroid A piece of space debris that crosses Earth's orbit.

Meteor The bright streak of light created when a meteoroid hits Earth's atmosphere.

Meteorite Any fragments of space rock that actually reach the ground.

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- Night sky observing with Pete Lawrence

You will be required to bring your own camera. Meteor photography requires the use of a DSLR (Digital Single Lens Reflex) or MILC (Mirrorless Interchangeable Lens Camera) type camera. A fast lens with a short focal length between 15-50mm is recommended. A tripod and lockable shutter release are required.

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Space telescopes of the FUTURE

Looking ever deeper into the Universe doesn't have to mean building increasingly bigger Hubble and JWST-style reflectors.

Ben Skuse considers whether there's another way

ISTOCK/LOCKHEED MARTIN

The \$8 billion-plus James Webb Space Telescope (JWST) will be the most advanced telescope ever sent into space when it's launched in 2020. Its discoveries will no doubt stagger humanity, just as the Hubble Space Telescope's have for the past 27 years. Yet the basic design and components for

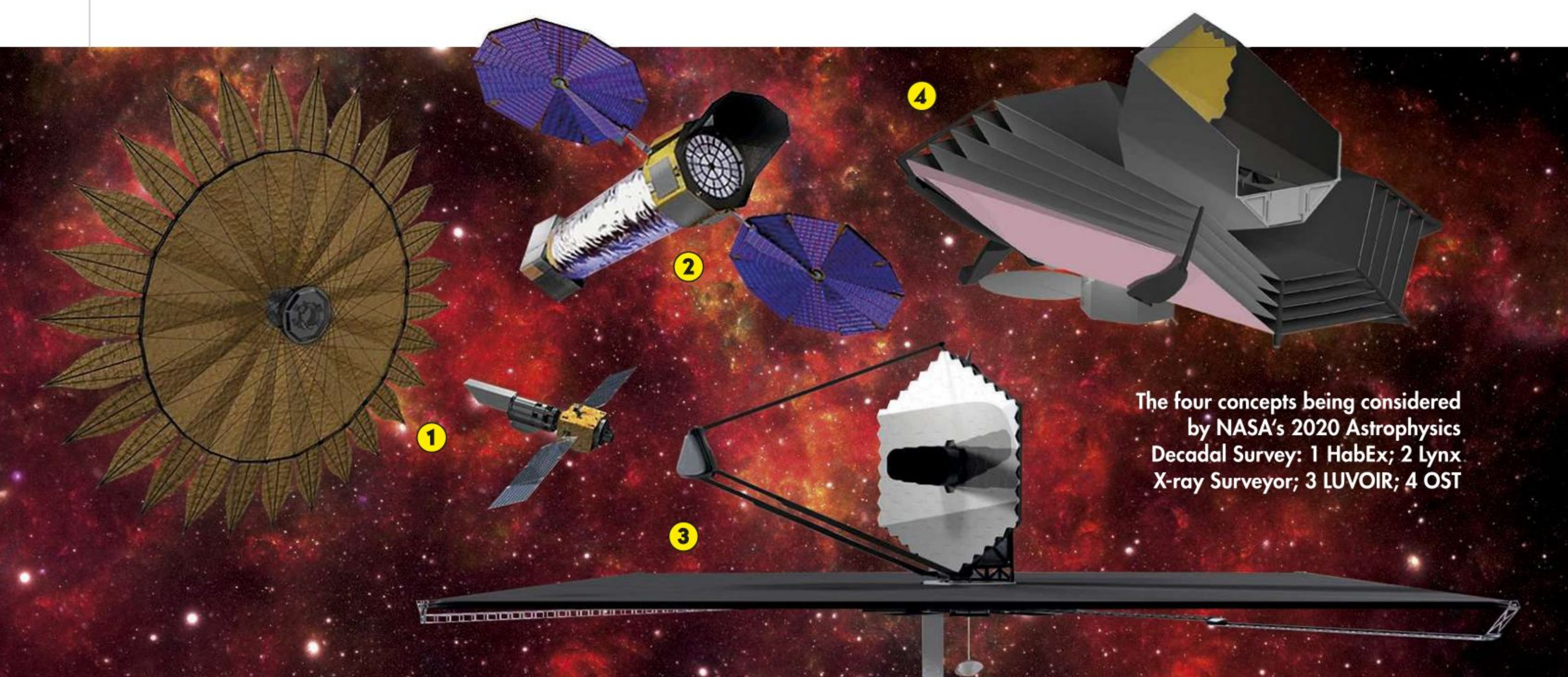
JWST, Hubble and almost all other space telescopes ever launched would easily be understood by Newton and his 17th-century contemporaries.

While the materials may be superior and detectors more sensitive, light is still collected by a big primary mirror, reflected to a smaller secondary mirror and then reflected back to a hole in the middle of the primary where – after

bouncing off a small tertiary mirror and a fine steering mirror to cancel out optical aberrations – the viewing apparatus (scientific instruments replacing the human eye) finally 'sees' the collected image. But with deeper imaging requiring telescopes with ever larger primary mirrors, how long will it be before space telescopes are simply too expensive or too big to fit in a rocket's nose cone? ►



It may look like a satellite but SPIDER is actually a new concept in telescopes based on vast arrays of tiny lenses



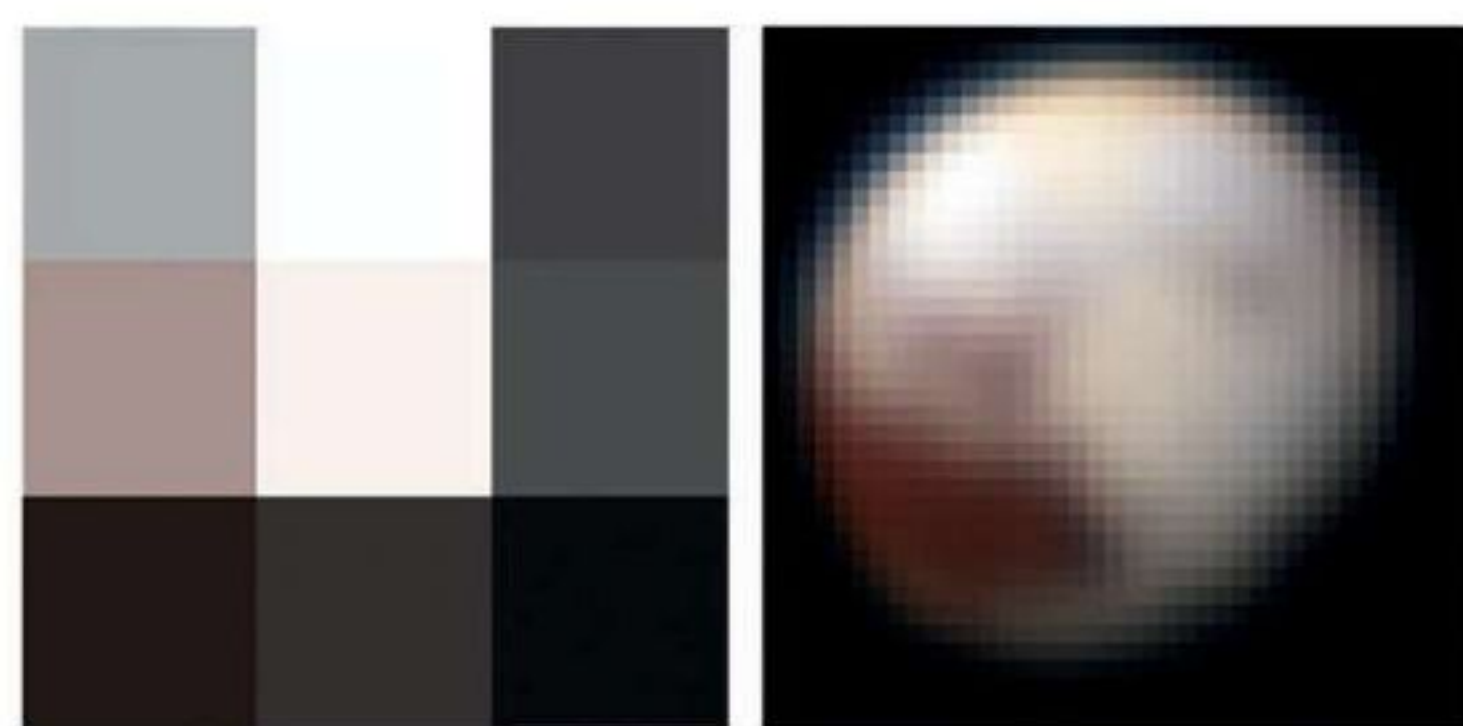
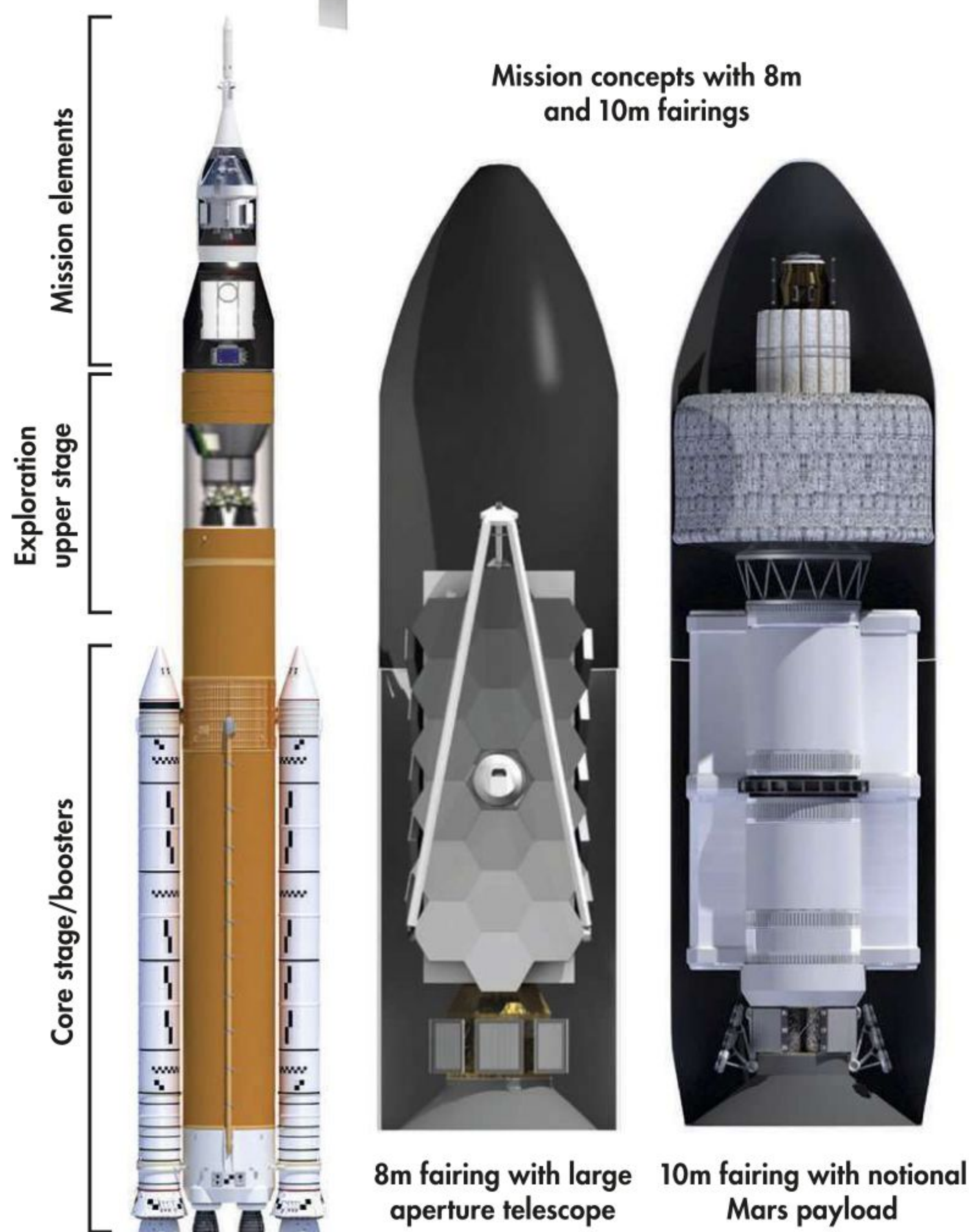
The four concepts being considered by NASA's 2020 Astrophysics Decadal Survey: 1 HabEx; 2 Lynx X-ray Surveyor; 3 LUVOIR; 4 OST

The immediate future

► Four mission concepts are being studied in preparation for NASA's 2020 Astrophysics Decadal Survey, the outcome of which could determine what NASA's flagship astrophysics mission for the mid-2030s will be. Two of these – Habitable Exoplanet Imaging Mission (HabEx) and Lynx X-ray Surveyor – are comparable or smaller in size to JWST and could be launched on an Ariane 5 rocket. The remaining pair – Large UV/Optical/IR Surveyor (LUVOIR) and Origins Space Telescope (OST) – both with proposed 8-15m primary mirrors, are simply too big.

For these concepts to be realised, bigger rocket nose cones (known as fairings) are required. Taking LUVOIR as an example; the study team is exploring two designs with either an 8m or 15m mirror depending on how big the available rockets will be in the 2030s. "The 8m LUVOIR mirror is the largest you can fit into a moderate-sized launch fairing, such as United Launch Alliance's Delta IV Heavy or Blue Origin's planned New Glenn," explains Aki Roberge, study scientist for the LUVOIR project. "The 15m version is the largest segmented mirror you can fold up (like the 6.5m JWST mirror) and fit into NASA's planned Space Launch System (SLS) fairing."

Ultimately designed for human missions to Mars, SLS will be the most powerful rocket ever built. "It's



Pluto with Hubble

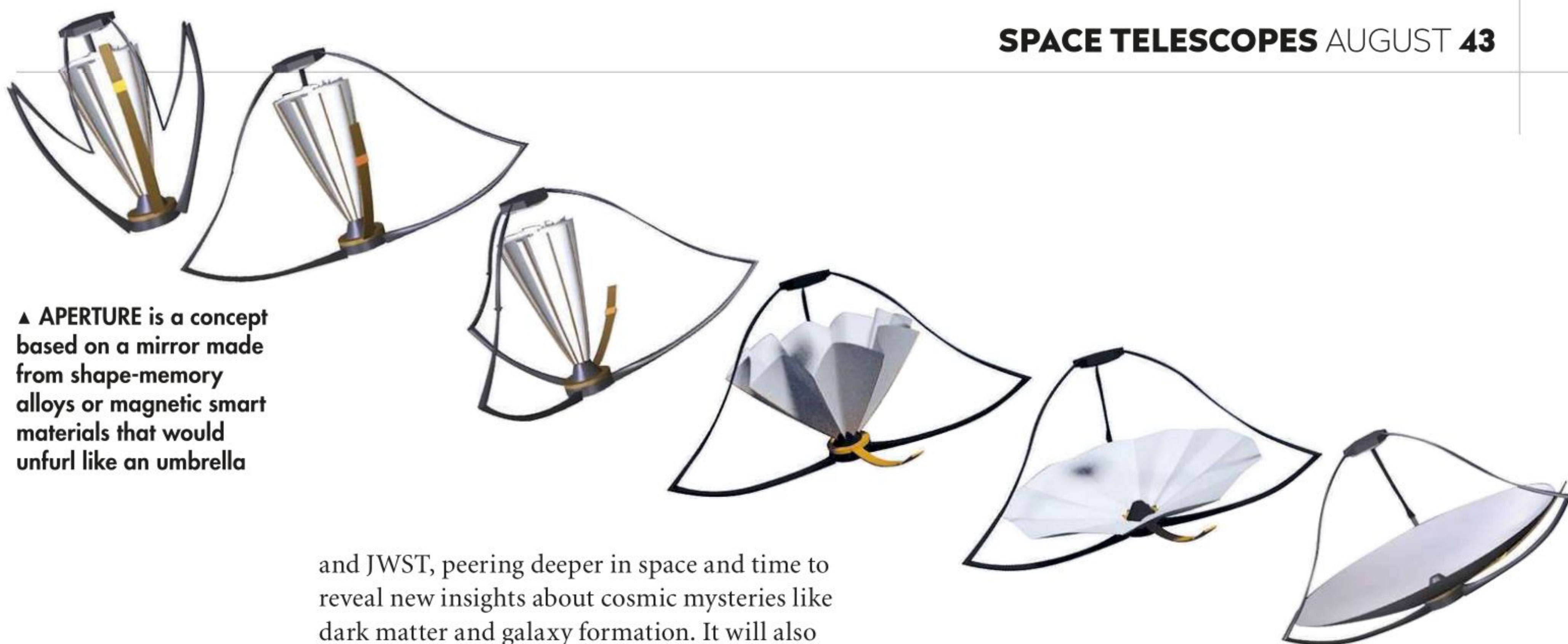
Pluto with LUVOIR

▲ The LUVOIR telescope might give us better views of Pluto, but even folded up it will barely fit in NASA's SLS

hard to imagine the need for a rocket larger than SLS, so telescopes larger than LUVOIR will have to be assembled in space, similar to the way the International Space Station was built," says Roberge. As a result, he believes LUVOIR – if commissioned – will likely be the last and largest telescope assembled on the ground and launched on a single rocket.

With its huge collecting area, LUVOIR will be able to perform studies impossible through Hubble

▲ NASA's planned SLS rocket will probably be the biggest rocket operating in the 2030s but the size of its fairing – the cargo-holding nose cone – will restrict the physical size of telescopes that can be taken into space



▲ **APERTURE** is a concept based on a mirror made from shape-memory alloys or magnetic smart materials that would unfurl like an umbrella

and JWST, peering deeper in space and time to reveal new insights about cosmic mysteries like dark matter and galaxy formation. It will also detect and characterise exoplanets around nearby stars, including potentially habitable worlds, while probing closer to home in order to monitor outer Solar System objects like Europa and Enceladus in fine detail.

Extending reflecting telescopes

Though LUVOR may signal the end of foldable telescopes like JWST, it may not be the last reflecting space telescope. Addressing how to build bigger reflecting telescopes, 'A Precise Extremely large Reflective Telescope Using Re-configurable Elements' (APERTURE) is an idea to engineer mirrors that unfurl like an umbrella. "But the process is not capable of producing mirrors of the quality necessary to image visible light," says Northwestern University's Melville Ulmer, who's leading the study.

Therefore, Ulmer and his team – funded by NASA Innovative Advanced Concepts (NIAC) – have been working on how to iron out the kinks in the mirror after deployment. Possibly made from shape-memory alloys or space-qualified membranes

and coated with magnetic smart materials, the mirror will be serviced by magnetic write heads that produce stress in the material and improve its shape post-deployment.

"Current rocket fairings would allow us to deliver 17m diameter mirrors," adds Ulmer. If the team can realise its ambition, not only will space telescopes that can see further and deeper into space become possible, but so will small (5x5cm), precisely controlled, deformable mirrors for coronagraphs used in exoplanet imaging as well as super-resolution, large area X-ray space telescopes (around 1km²).

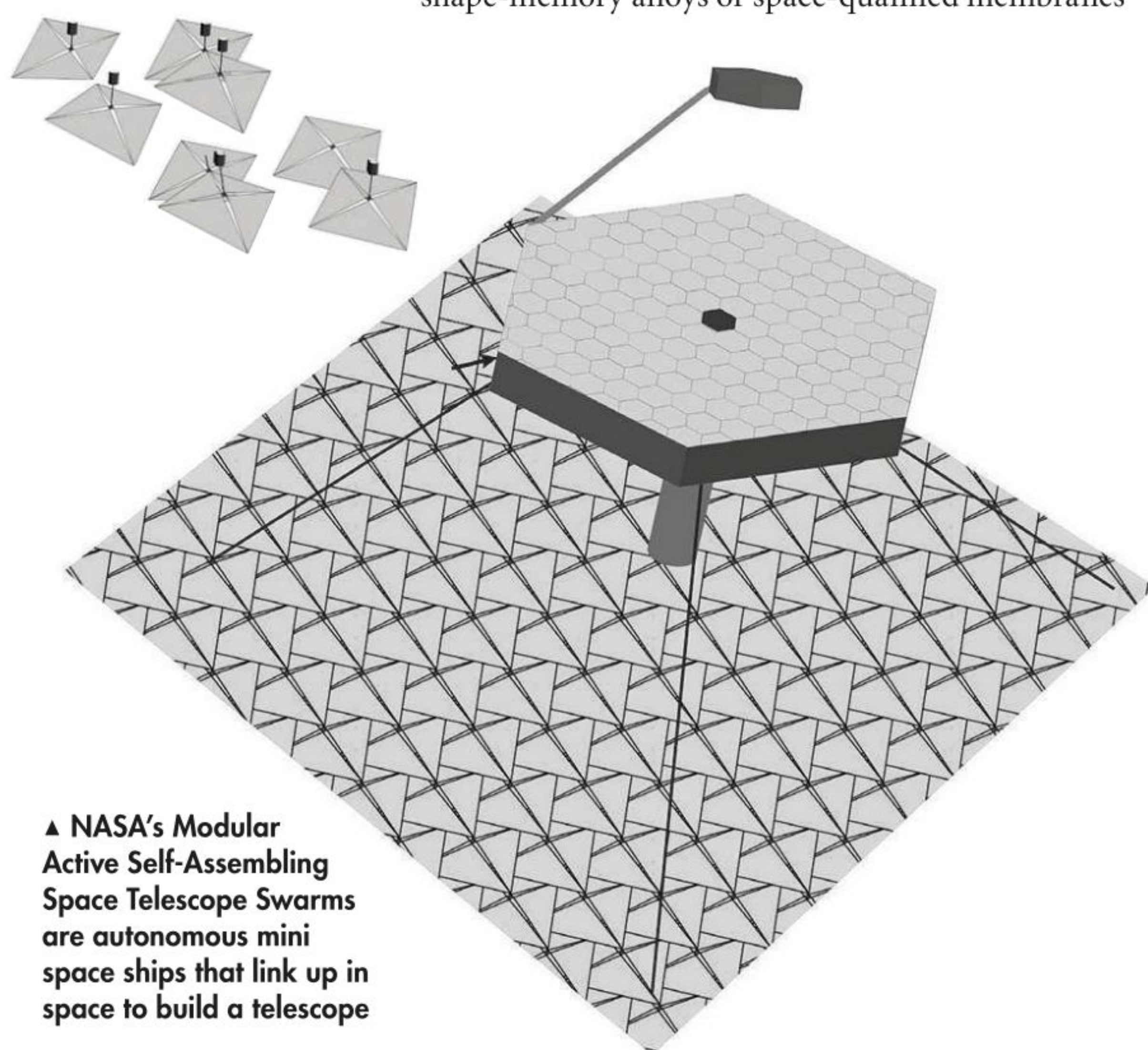
Another NIAC-funded study called 'Modular Active Self-Assembling Space Telescope Swarms' takes a different approach. This project aims to explore a space telescope that fits together like Lego bricks in space. The idea is that these small 1m-wide parts will be added as extra payloads to pre-planned missions, and then travel by solar sail to a chosen site, where they will autonomously accrue and self-assemble into a fully-fledged telescope.

"The concept is an attempt to address the inherent difficulties in constructing and launching a giant space telescope," adds Dmitry Savransky, Cornell University scientist and project lead. "Mass producing these parts will bring down costs, and the use of multiple launches (and especially payloads of opportunity) means there is no single point of failure in the system, so the overall mission is likely to succeed even with the failure of an individual module or launch."

Savransky believes the concept could be employed to construct Hubble-style reflector telescopes of over 30m in space. Such huge apertures would be able to explore the nature of dark matter and energy, and observe much fainter and distant sources, such as potentially life-accommodating exoplanets.

The future is flat

Lockheed Martin's Segmented Planar Imaging Detector for Electro-Optical Reconnaissance (SPIDER) concept posits another approach to reducing the size of space telescopes, ditching large, bulky mirrors in favour of a thin array of tiny lenses. Borrowing a concept from large-scale interferometer arrays located in observatories ►



▲ **NASA's Modular Active Self-Assembling Space Telescope Swarms** are autonomous mini space ships that link up in space to build a telescope

► around the world, the idea is to combine the light the telescope collects in pairs to form interference fringes. The amplitude and phase of these fringes are measured and used to digitally construct the image.

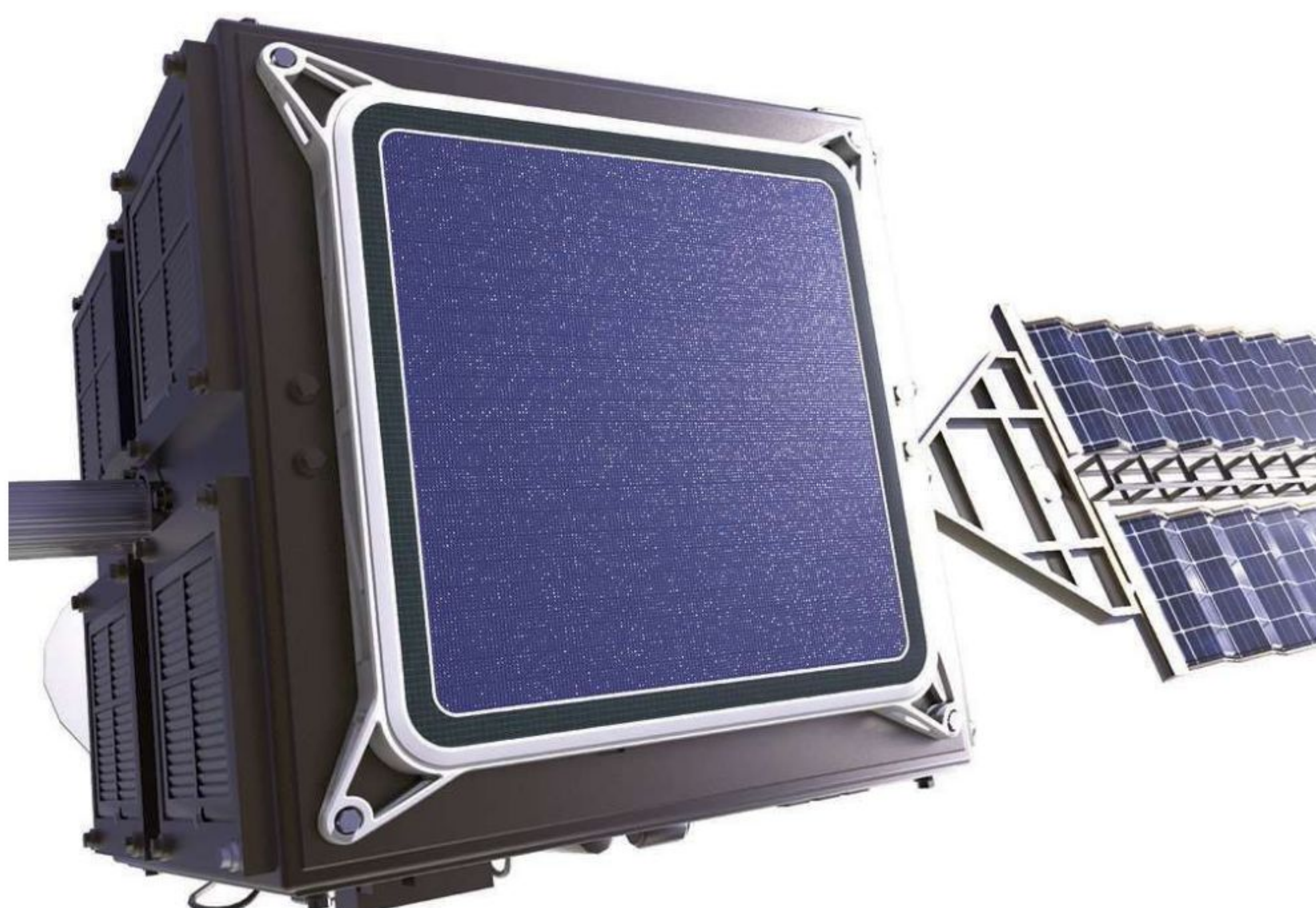
Interferometry is a well-known technique, but SPIDER's unique selling point is its diminutive size and weight. Replacing complex combining optics with silicon-chip photonic integrated circuits, "we take pieces of a scene directly into our micro lenses, which connect directly into circuits that will process the signals into an image," says SPIDER programme manager Greg Feller. This makes the instrument completely flat and shrinks its weight by 90 per cent, while maintaining excellent resolution.

Though not a replacement for traditional reflecting telescopes conducting deep space imaging – because the interferometer requires a well-lit and extended scene in order to generate the best images – SPIDER's weight, size and affordability make it ideal for planetary missions.

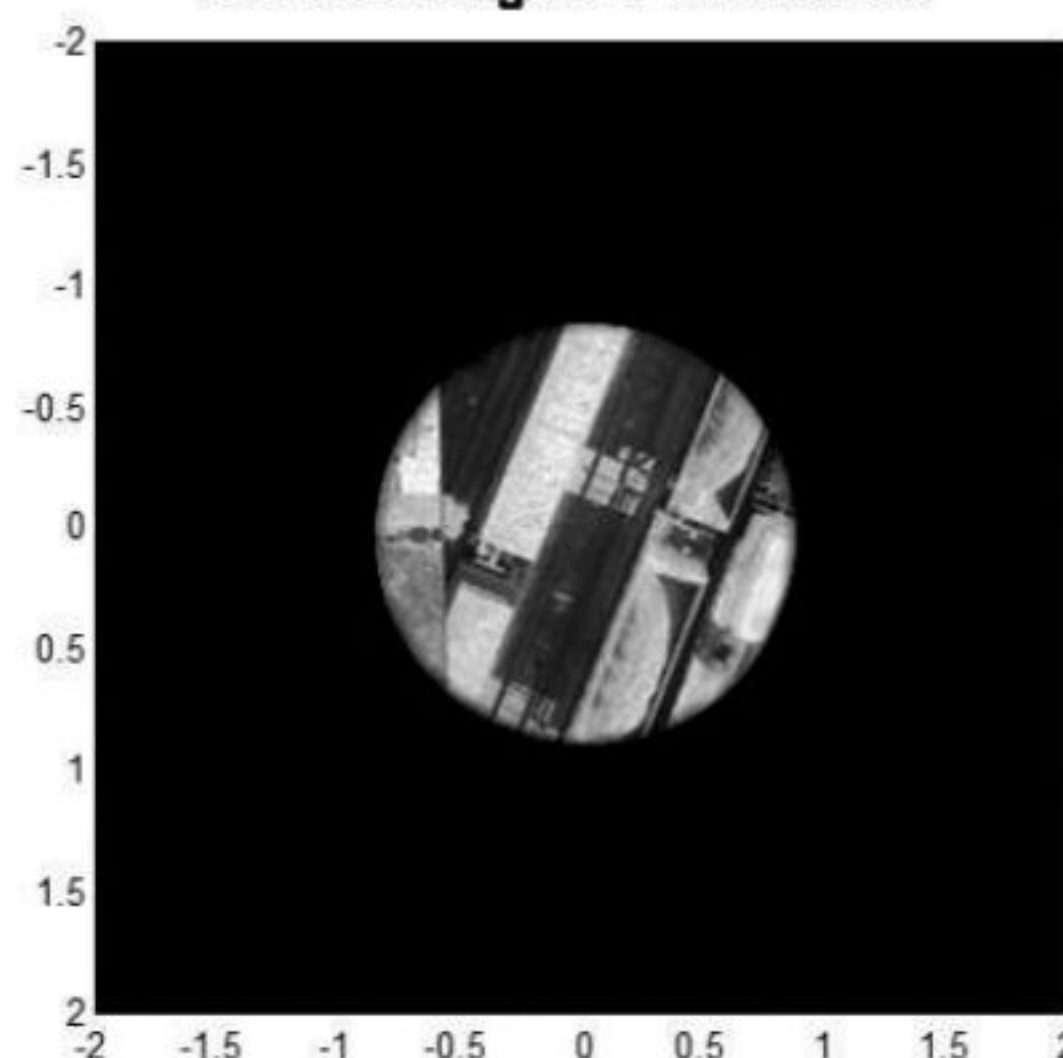
Last year, the team built a prototype of the SPIDER system, engineering a row of 30 lenses each less than a millimetre wide. They then created two scenes – a standard bar test pattern and an overhead view of a complex railway yard – and made them seem 450km distant using a mirror assembly. By rotating the two scenes viewed by the row of tiny lenses, they managed to simulate what a larger instrument would be able to see.

Feller is now overseeing the construction of the full instrument, which will boast over 500 lenses, to show how the device can operate when fully integrated. He's optimistic about SPIDER's future: "We could launch the first SPIDER in space on an experimental mission early in the coming decade."

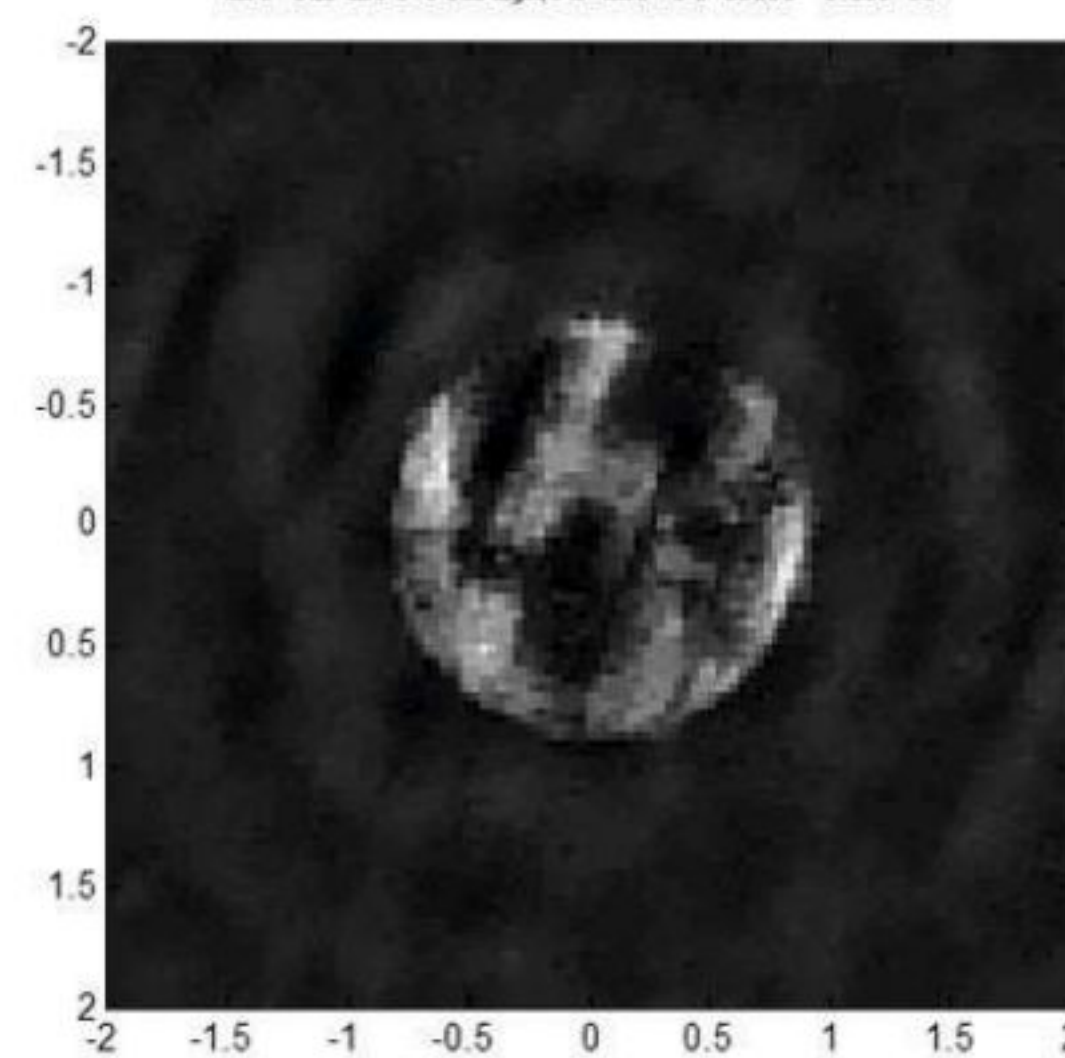
Elsewhere, serial inventor Ali Hajimiri from the California Institute of Technology has designed a small phased array capable of forming images from a flat surface without any lenses at all – a lensless camera. Reversing the way in which phased array communication transmitters focus and steer radio waves in a particular direction, the device controls the relative timing of a large number of



SPIDER Target 2: Train Yard



SPIDER Result 2: Train Yard



receiving elements to create 'gazing beams' that selectively look at a small part of the field of view.

Last year, Hajimiri and his team demonstrated the technology by engineering a chip consisting of an 8x8 grid with 64 sensors. The chip managed to capture a low-resolution image of a barcode. But with more light-collecting elements, its sensitivity and resolution will increase dramatically.

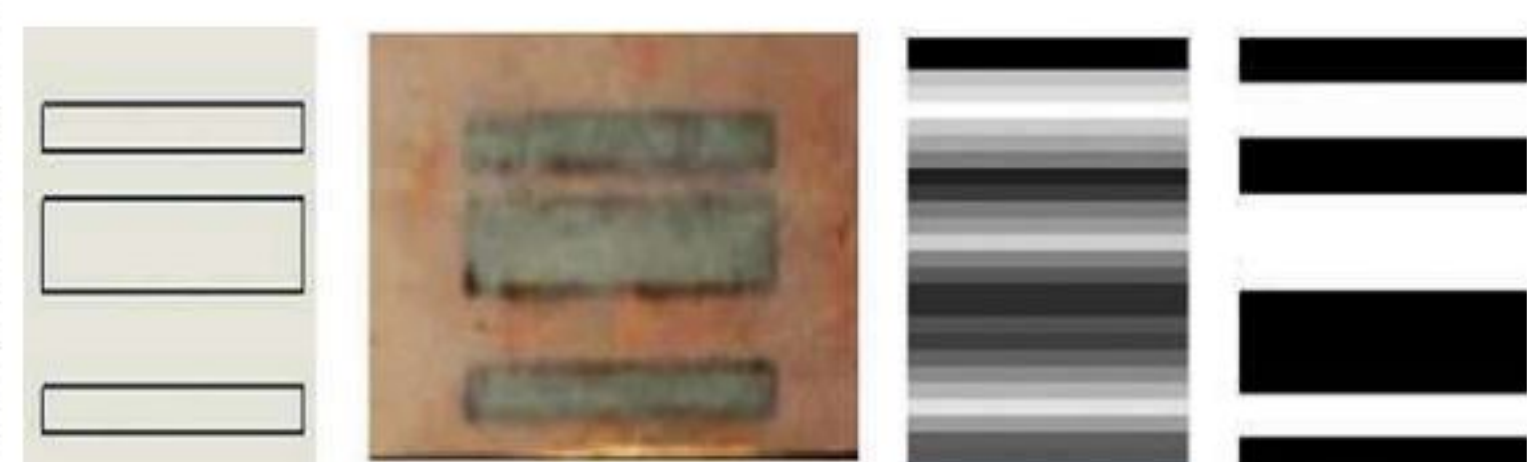
"The technology does not need a depth associated with a refractive (lens-based) or reflective (mirror-based) telescope and hence can be deployed as a large, thin sail serving as a telescope," says Hajimiri.

Cosmic concepts

Early-stage conceptual studies of ideas that would be unrecognisable to today's astronomers are also being performed. The Kilometer Space Telescope (KST), for instance, is another NIAC-funded project that would have over three times the diameter and 10 times the collecting area of the Arecibo radio telescope in Puerto Rico.

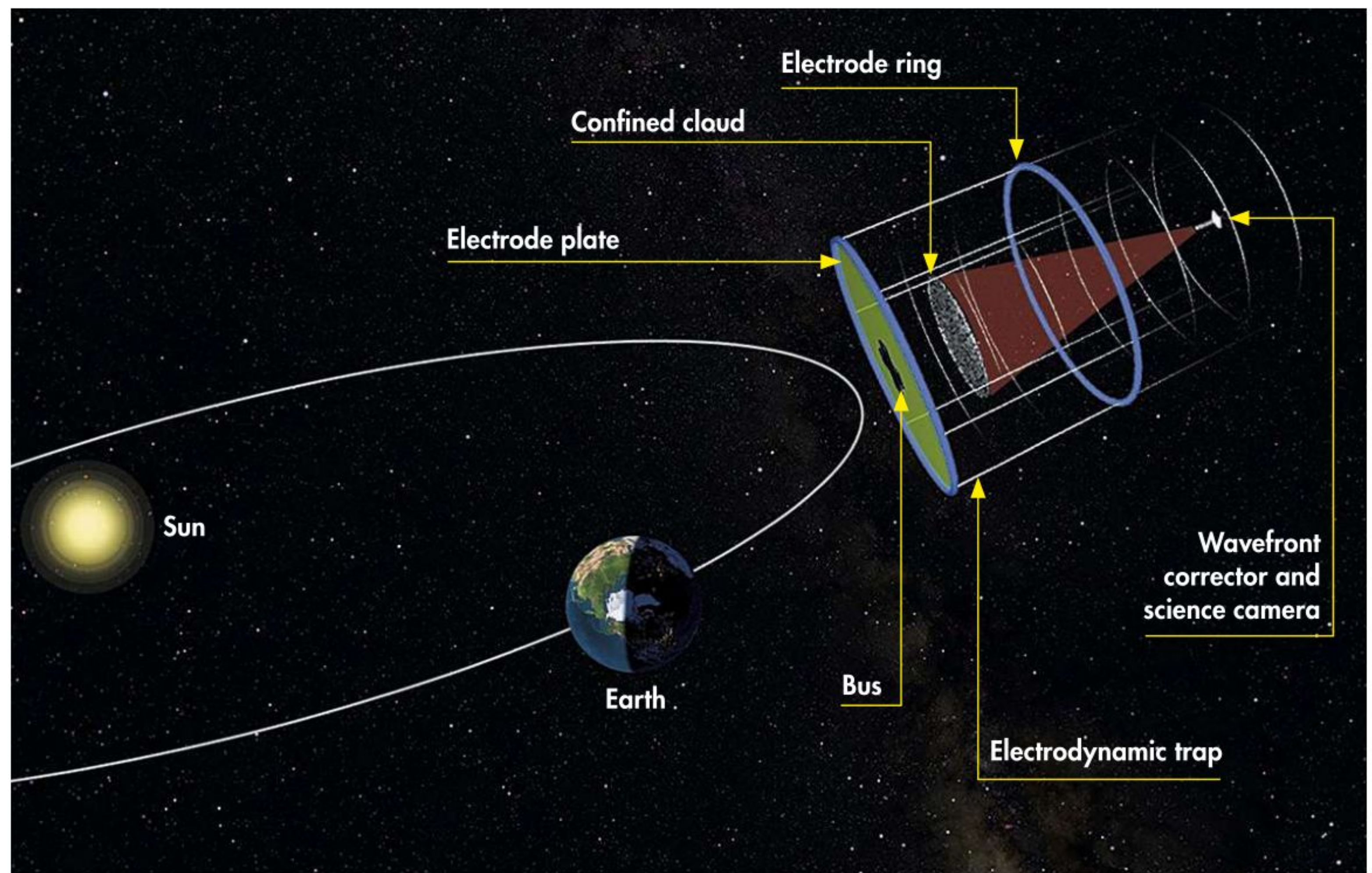
As the name suggests, the main component of the KST is a single, vast kilometre-diameter filled aperture. The key to realising such a huge collecting area is designing inflatable polymer bubbles which become rigid upon sufficient exposure to UV radiation from the Sun. The bubbles would then

▲ Above are the results of the prototype SPIDER system, which used 30 lenses each under a millimetre wide. Left is the target image – a railway yard – and on the right is SPIDER's reconstruction



▲ Tests for Ali Hajimiri's lensless camera – which takes its inspiration from phased array transmitters – managed to scan and reconstruct a specially designed barcode

► The concept for NASA's Orbital Rainbows project: a trapped cloud of highly reflective grains operates as the mirror



be cut in space and given a highly reflective coating to form a vast spherical mirror.

"We expect KST technology will give us 400 times better resolution than Hubble, using a light collection area 160,000 times greater," says Wallis Laughrey, vice president of Space Systems at Raytheon Space and Airborne Systems. "To use an analogy, Hubble sees 'toddler galaxies', Webb will see 'babies' and KST will see galaxies before they were born."

The inflated structures KST relies on could also form interferometer arrays, or act as giant star shades for exoplanet-hunting telescopes, blocking the line of sight to a host star but not its planets. Though lightweight and capable of forming vast telescope structures compared to today's standards, even KST is limited in terms of size and cost.

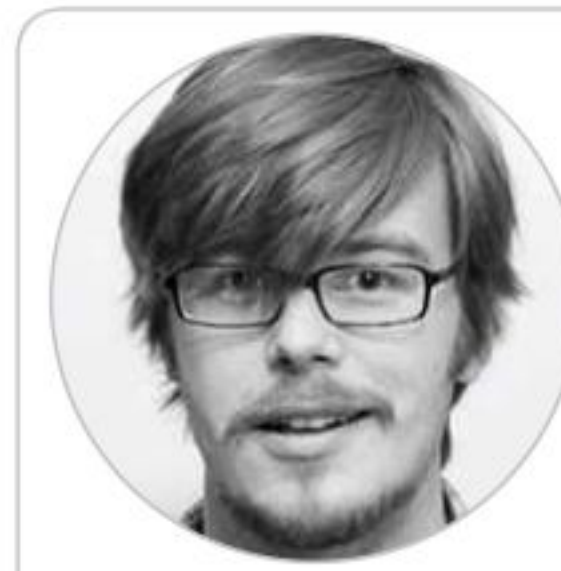
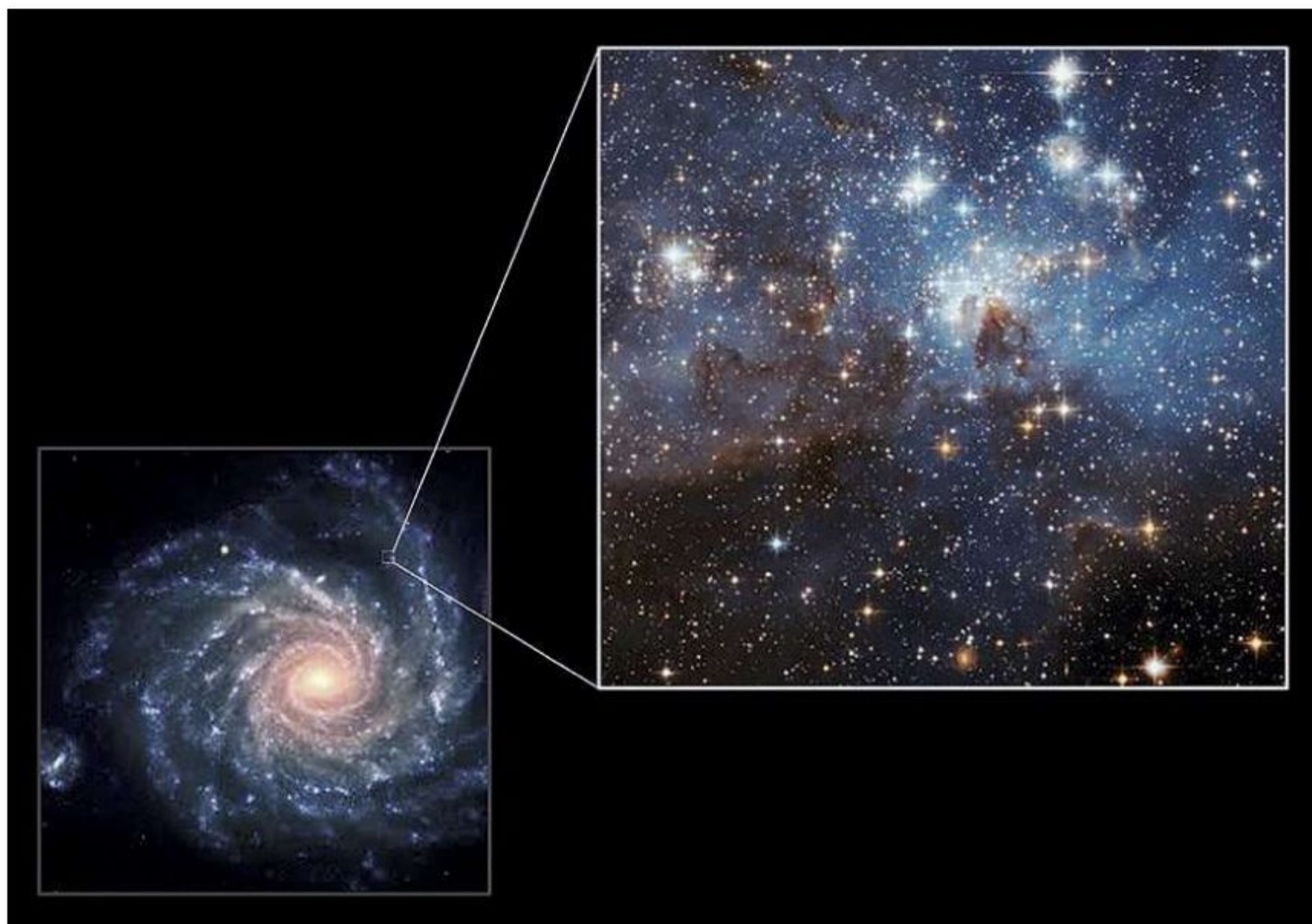
Inspired by how water droplets form rainbows here on Earth, NIAC-funded Orbiting Rainbows, in contrast, envisions replacing solid mirrors with

potentially vast clouds of reflective micron-sized glitter-like particles. Consisting of a primary aperture made up of a cloud of millions of particles and a confinement system (electric, magnetic or light pressure); a secondary aperture that would also include a correction system and the science camera; and a module controlling the particle cloud, the various parts of the telescope would be free-flying and kept in formation at the same position where JWST will be parked.

One image from the particle cloud interacting with light from distant objects would be a mess. But studies on Earth using laser light to represent the object and arts-and-crafts glitter to represent the particle cloud have shown that by taking and combining multiple images, then deconvoluting the data using powerful algorithms, a clear picture emerges. "Orbital Rainbows would be relatively simple to package, transport and deploy," says Marco Quadrelli from NASA's Jet Propulsion Laboratory (JPL), the project's principal investigator. "It would be reconfigurable and could be re-targeted; the focal length would be variable, and ultimately it would also be self-healing and disposable."

He suggests the system could be used to detect exoplanets, and then image their surface features and hunt for molecular signs of life. However, with significant advances in adaptive optics and computational imaging required, it will take 10–20 years for the technology to mature to a point where 'cloud optics' is deployed in space. **S**

▼ The Kilometer Space Telescope (KST) will have a resolution 400 times that of Hubble, so a single pixel from a galaxy in the Fornax Cluster (two million lightyears away) could have the detail of a Hubble image of the Large Magellanic Cloud (a mere 163,000 lightyears away)



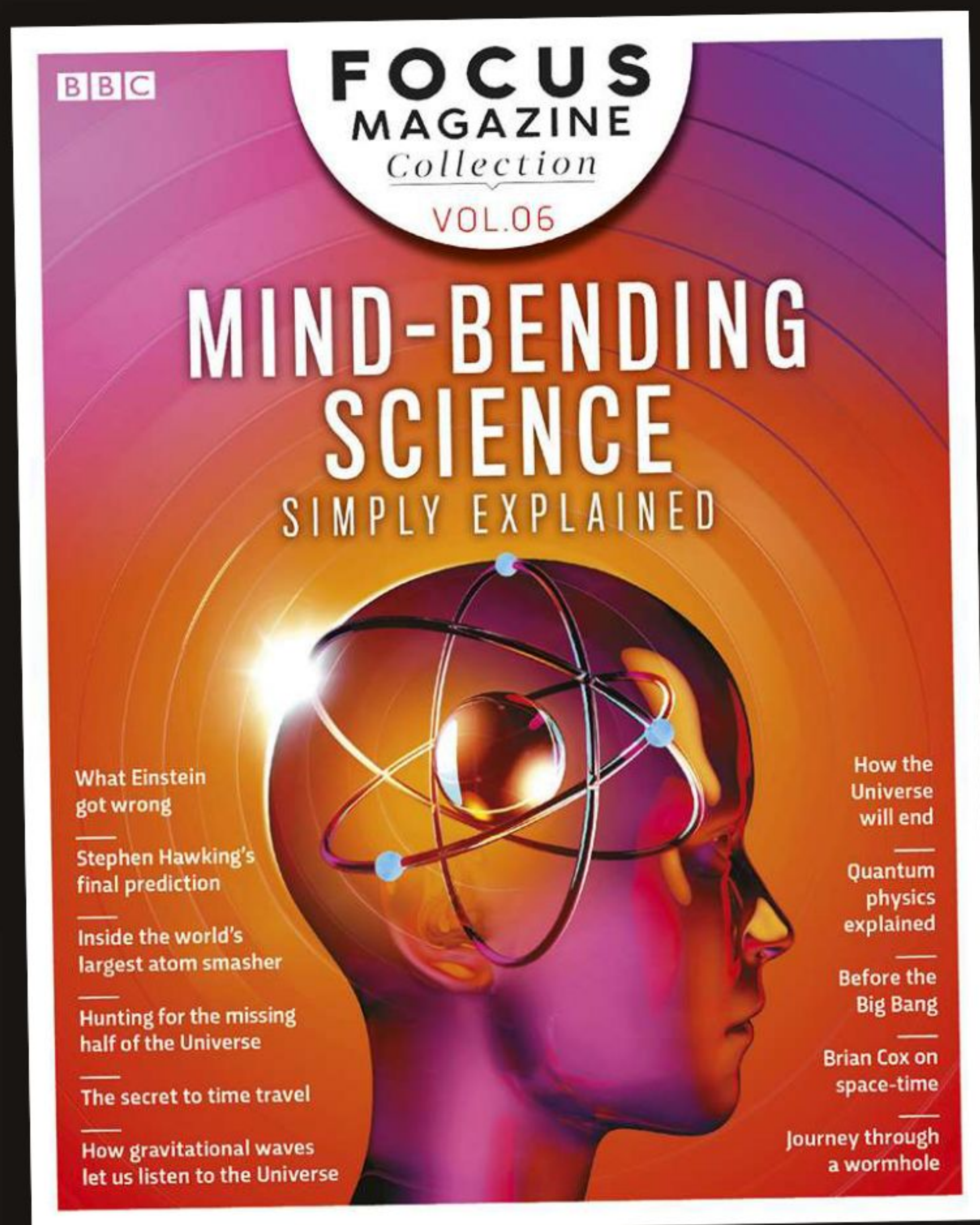
ABOUT THE WRITER

Dr Benjamin Skuse earned a PhD in Applied Mathematics at Edinburgh University before becoming a science writer based in Bristol, UK

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The Sky Guide August

The 2018 **Perseid meteor shower** peak coincides with new Moon. If the weather is clear this year's display should be one to remember

PETE LAWRENCE

ABOUT THE WRITERS

Pete Lawrence is an astronomer and astro imager, who presents *The Sky at Night* monthly on BBC Four



Stephen Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 58



RED LIGHT FRIENDLY

To preserve your night vision, this Sky Guide can be read using a red light under dark skies



DON'T MISS...

- ◆ Venus at half phase
- ◆ Comet 21P/Giacobini-Zinner visible all night long
- ◆ Various daylight transits of Jupiter's moons Io, Europa and Ganymede



AUGUST HIGHLIGHTS

Your guide to the night sky this month

THURSDAY

2 A very brief double shadow transit of Io's and Europa's shadows can be seen from 21:20 BST (20:20 UT) until 22:00 BST (21:00 UT). Jupiter will be low in the southwest as the event concludes.

MONDAY

6 This morning's 35%-lit waning crescent Moon is nicely positioned in Taurus, south of the Pleiades and west of the V-shaped Hyades.

TUESDAY

7 A low telescopic view of Jupiter will make it look as if the planet has gained another 'moon'. It is, in fact, the mag. +8.8 star TYC 6155-930-1. As Jupiter appears to move in the foreground so the star appears to the east of the planet, just south of actual moon Io.

SATURDAY ►

11 There is a partial solar eclipse today which is just visible as a tiny indent in the Sun's disc if you're north of John o' Groats. The very north of Shetland will experience the greatest partial eclipse around 09:45 BST (08:45 UT).

MONDAY

13 Comet 21P/ Giacobini-Zinner (more of which on page 57) is approximately 1° from the 7th magnitude open cluster Stock 5 in Cassiopeia today.

TUESDAY ►

14 See if you can spot the waxing crescent Moon due south at an altitude placing it a little under halfway up the sky at 16:00 BST (15:00 UT). Then look 5.5° – or 11x the apparent diameter of the lunar disc – south of its position and see if you can spot Venus.

THURSDAY

16 Comet 21P/ Giacobini-Zinner passes the Heart (IC 1805) and Soul (Westerhout 5) nebula pairing by around 3° between 16-19 August.

FRIDAY

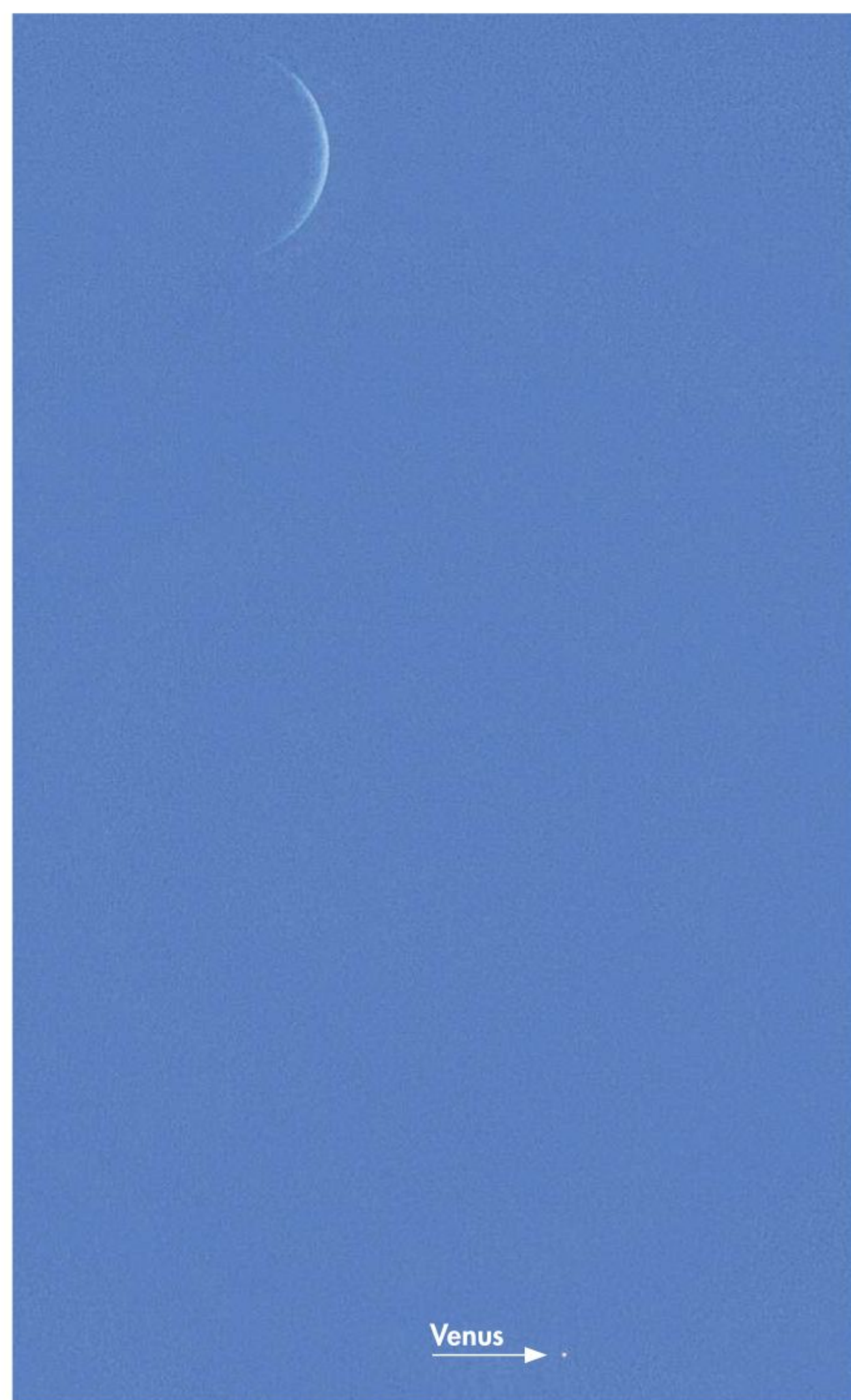
17 Look towards the southwest at 21:30 BST (20:30 UT) to see mag. -1.9 Jupiter and a 45%-lit waxing crescent Moon separated by 5°.

Venus reaches greatest eastern elongation today when it will appear separated from the Sun by 45.9°.



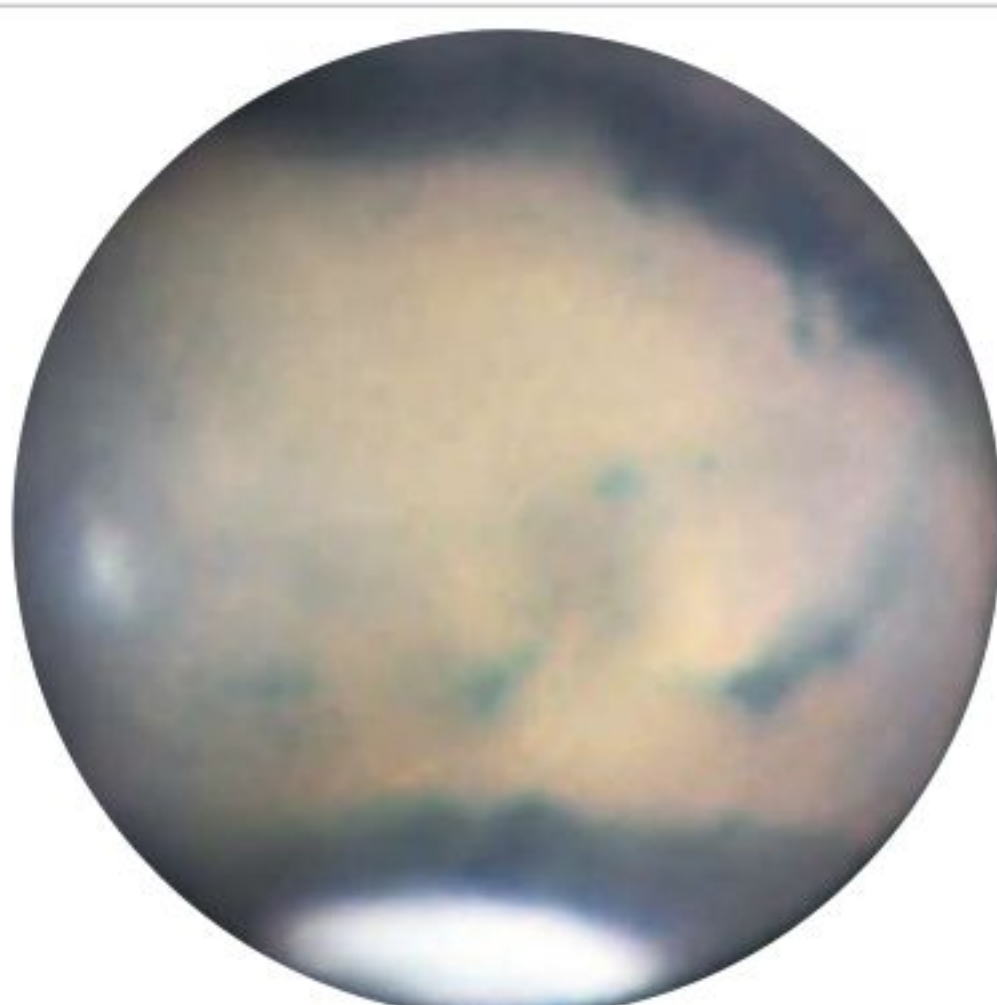
◀ SUNDAY

19 Comet 21P/ Giacobini-Zinner passes the southern extremities of the 7th magnitude open cluster Trumpler 3 in Cassiopeia on the night of 18/19 August, being located approximately 12 arcminutes from the cluster at 01:00 BST (00:00 UT) on 19 August.



THURSDAY ►

23 The Moon's monthly planetary visits continue today as it passes 6.5° to the north of mag. -2.3 Mars. There's something quite compelling about this meeting as the brilliant salmon pink-coloured Mars contrasts well with the silvery grey Moon.



SUNDAY

26 Mercury reaches greatest western elongation when the Solar System's innermost planet can be seen separated from the Sun by 18.3° in the morning sky. Mag. +0.1 Mercury is best seen low above the east-northeast horizon just after 05:00 BST (04:00 UT).

MONDAY

27 Another event suitable for this month's Challenge on page 59 – a daylight double transit of Io's and Europa's shadows visible between 16:50 BST and 18:10 BST. (15:50 UT and 17:10 UT).



WEDNESDAY


15

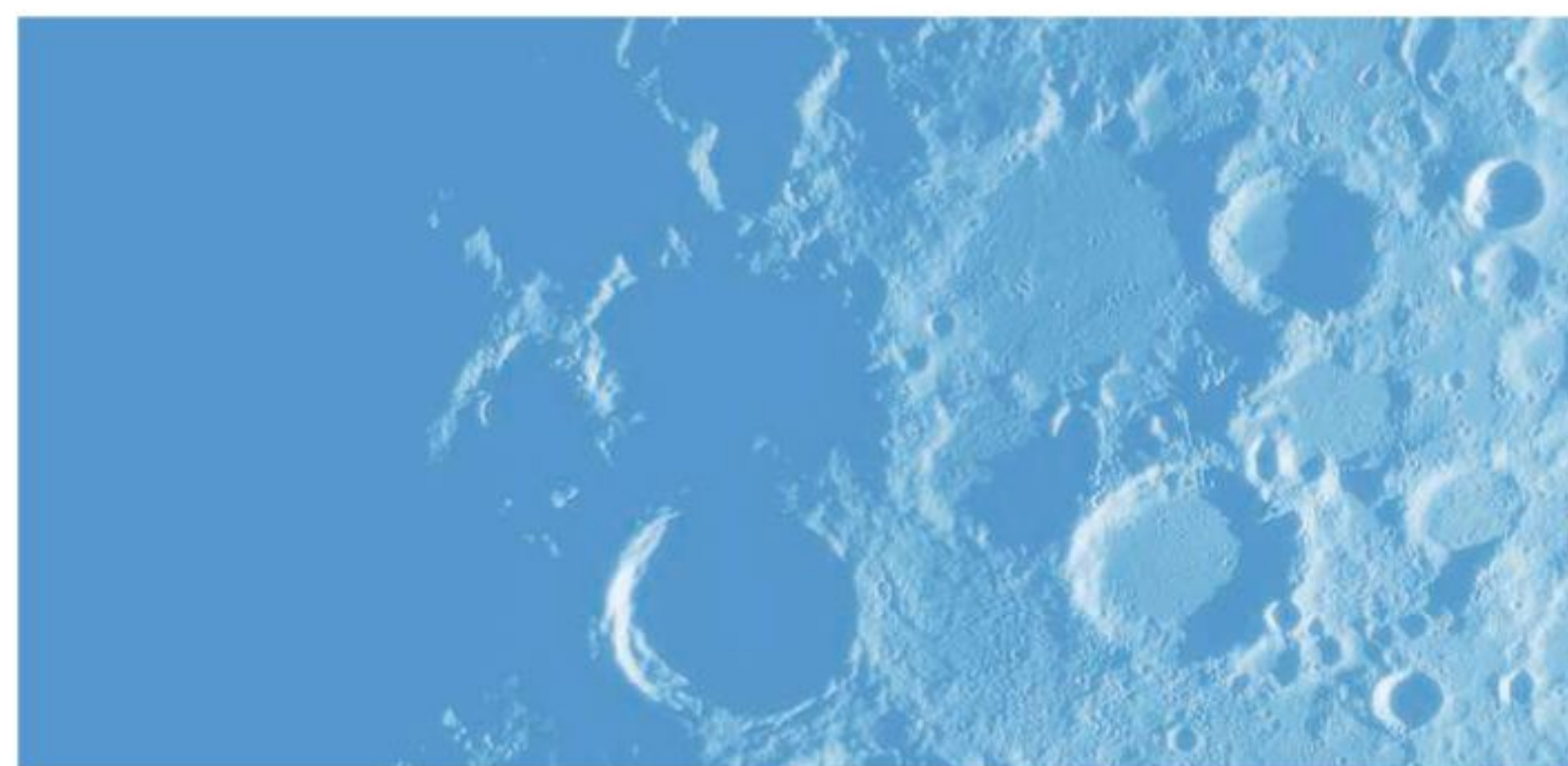
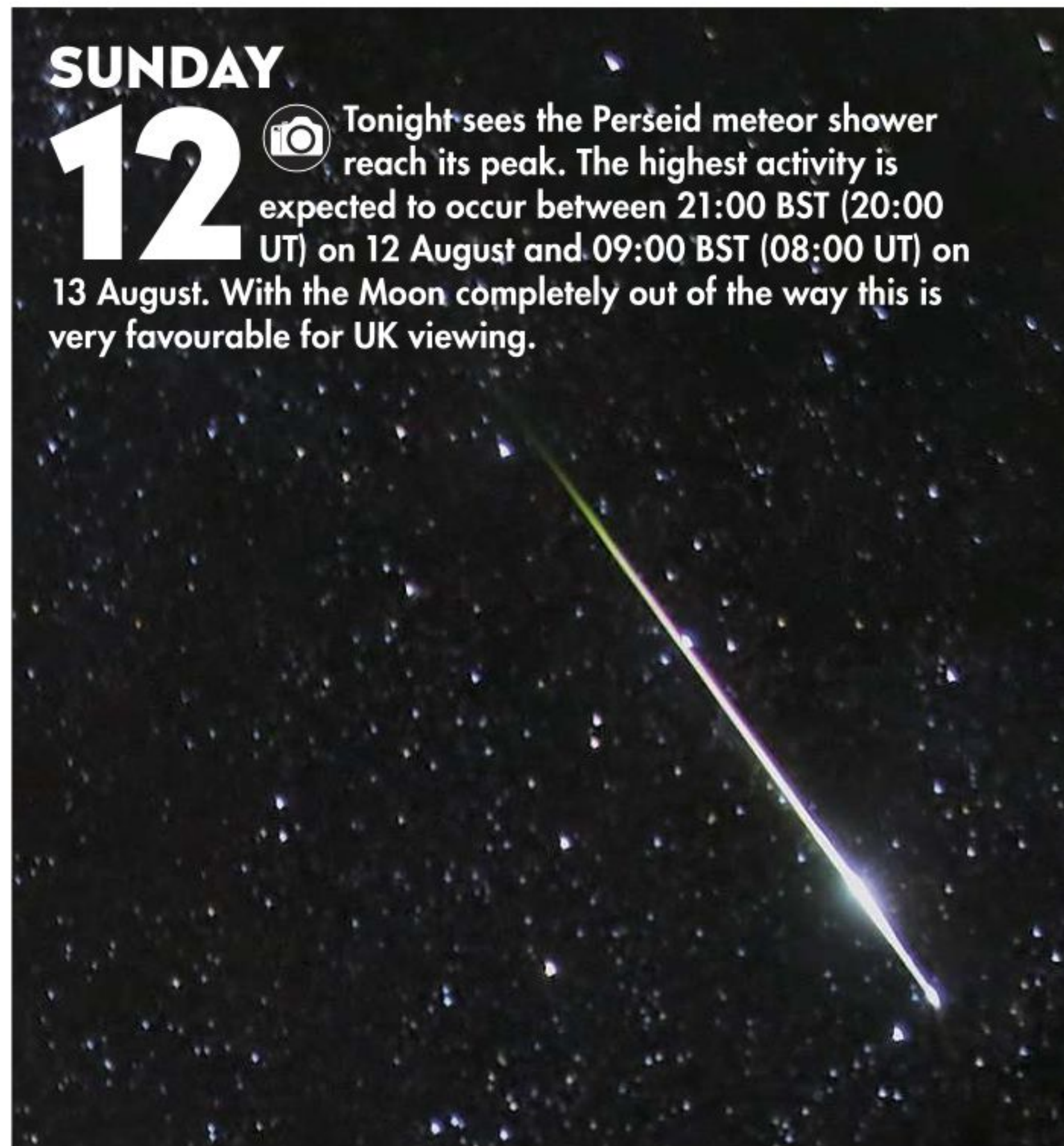
Today Venus should reach dichotomy, or 50% illumination.

However, the Schröter effect typically means that the planet reaches this phase a few days early when it's in the evening sky. Turn to page 51 for more about this phenomenon.

SUNDAY


12

 Tonight sees the Perseid meteor shower reach its peak. The highest activity is expected to occur between 21:00 BST (20:00 UT) on 12 August and 09:00 BST (08:00 UT) on 13 August. With the Moon completely out of the way this is very favourable for UK viewing.




◀ SATURDAY

18

 There's an opportunity to see *clair obscur* effect the Lunar X this afternoon. The X will appear about one-third of the way up the terminator from the Moon's southern limb. Making things more challenging, the peak appearance occurs in daylight at 18:30 BST (17:30 UT).

MONDAY

20

 There's a double transit today involving Io's and Europa's shadows; perfect timing for this month's Sky Guide Challenge (page 59).

The event starts as Jupiter rises around 14:15 BST (13:15 UT) and concludes two hours later with Jupiter at an altitude of 16°.

TUESDAY ▶

21

 Saturn appears a little over 5° to the west of the 81%-lit waxing gibbous Moon this evening. Catch the pair due south around 21:30 BST (20:30 UT).



WEDNESDAY

29

The final daylight planet event for this month's Sky Guide Challenge is a cracker.

Ganymede's shadow can be seen crossing Jupiter from 13:40 BST (12:40 UT), when the planet will have an altitude of just 5°. By 15:50 BST (14:50 UT) it'll be up to 17°.

FAMILY STARGAZING - 9-16 AUG



As new Moon coincides with the peak of the Perseid shower, 2018 is a great year to introduce youngsters to meteor watching. Find a dark location away from stray lights. A sunbed per person is an ideal way to observe the shower in comfort. Plenty of warm drinks or soup should help keep spirits up until the magical moment when the first meteor is seen. Then have a game of who can spot the most. Activity should be best between 9-16 August and although rates increase after 01:00 BST (00:00 UT) there should still be trails visible earlier in the evening.

www.bbc.co.uk/cbeebies/shows/stargazing



NEED TO KNOW

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'.



FAMILY FRIENDLY

Objects marked with this icon are perfect for showing to children



NAKED EYE

Allow 20 minutes for your eyes to become dark-adapted



PHOTO OPPORTUNITY

Use a CCD, planetary camera or standard DSLR



BINOCULARS

10x50 recommended



SMALL/ MEDIUM SCOPE

Reflector/SCT under 6 inches, refractor under 4 inches



LARGE SCOPE

Reflector/SCT over 6 inches, refractor over 4 inches



GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing a scope.

THE BIG THREE

The three top sights to observe or image this month

DON'T MISS

► Look out for lots and lots of these trails emanating from between Cassiopeia and Perseus in mid August

Favourable Perseids

WHEN: 9-16 August, peak on 12/13 August



The Perseid meteor shower peaks this month and thanks to August nights being relatively mild and short, this is one of the most popular of the annual showers to watch. The shower's high peak activity rate means that an all-night session can really deliver some rich rewards.

The shower occurs when Earth passes through dust spread around the orbit of comet 109P/Swift-Tuttle. The first encounters typically take place around 23 July when the particle density and meteor rates are low. As the nights pass, Earth moves deeper into the dust stream until on the night of 12/13 August the meteor shower reaches its peak.

The number of meteors you can expect to see at this point is expressed as the shower's zenithal hourly rate (ZHR) and for the Perseids this is predicted to be between 80-110 meteors per hour. The ZHR is a misleading figure because it doesn't represent the true number of meteors you should expect to see. ZHR is a normalised value assuming perfect skies, a view of the whole sky at once and the shower radiant being directly overhead (the radiant being the point in the sky from which the shower trails appear to emanate). Typically none of these factors are achieved and variations from perfect conditions reduce the actual number of meteors seen.

A big influencing factor is the clarity of the sky. Obviously the Moon has a big effect when present. Luckily, this year it isn't. New Moon occurs on 11 August giving us the best possible conditions... so long as the weather plays ball!

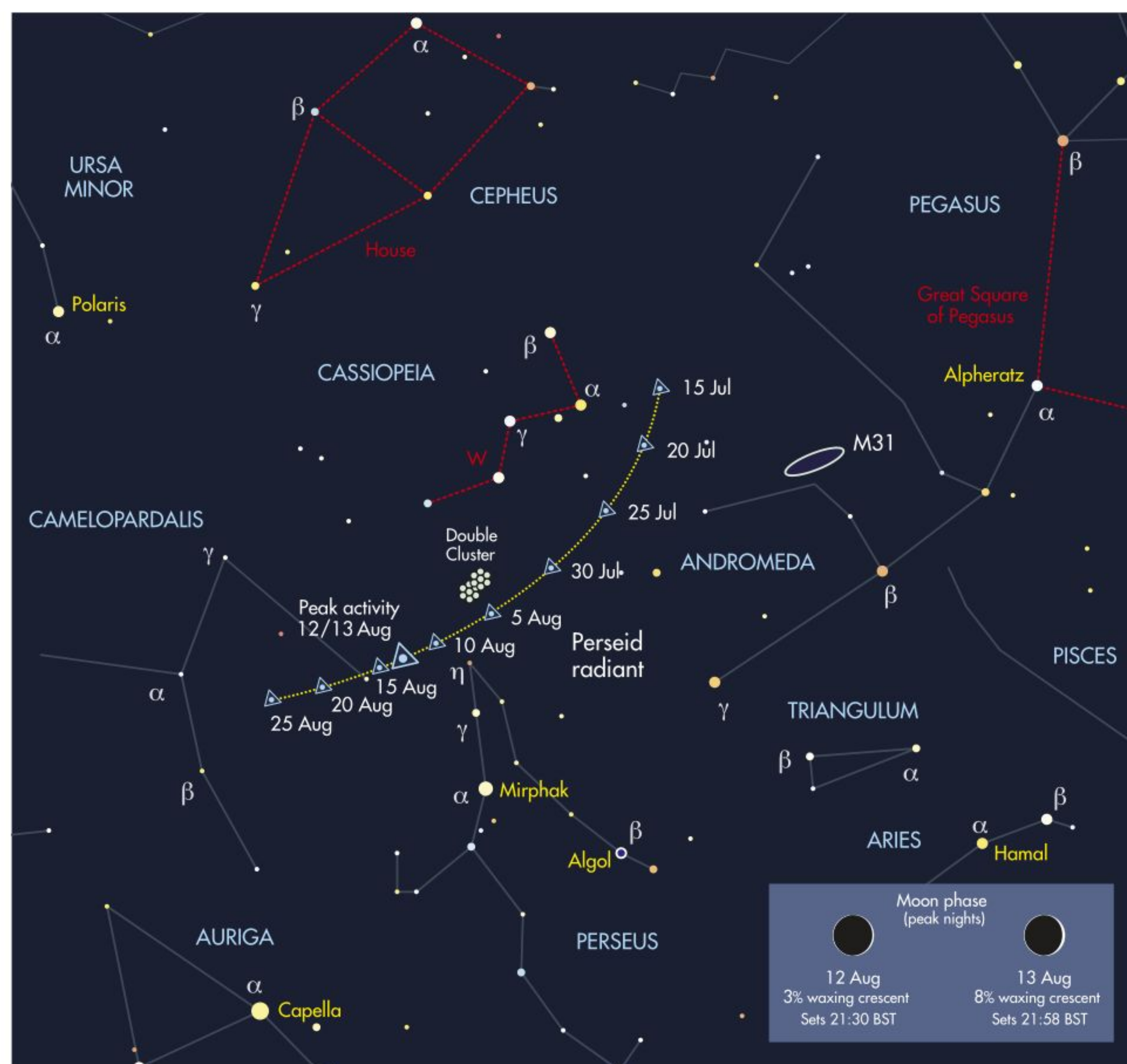
The period of peak activity is expected to occur between 21:00 BST (20:00 UT)

on 12 August and 09:00 BST (08:00 UT) on 13 August. From the UK the highest concentration will be seen between 01:00 BST (00:00 UT) on 13 August and the onset of dawn on the same day. However, activity is typically quite reasonable throughout 9-16 August. Outside of this range Perseid rates are typically quite low.

The best way to see the shower is to arrange a sunbed in a dark spot so that you're looking up at an angle of around 60°. Any direction is good but we would

recommend looking south earlier in the evening and east later in the night towards dawn.

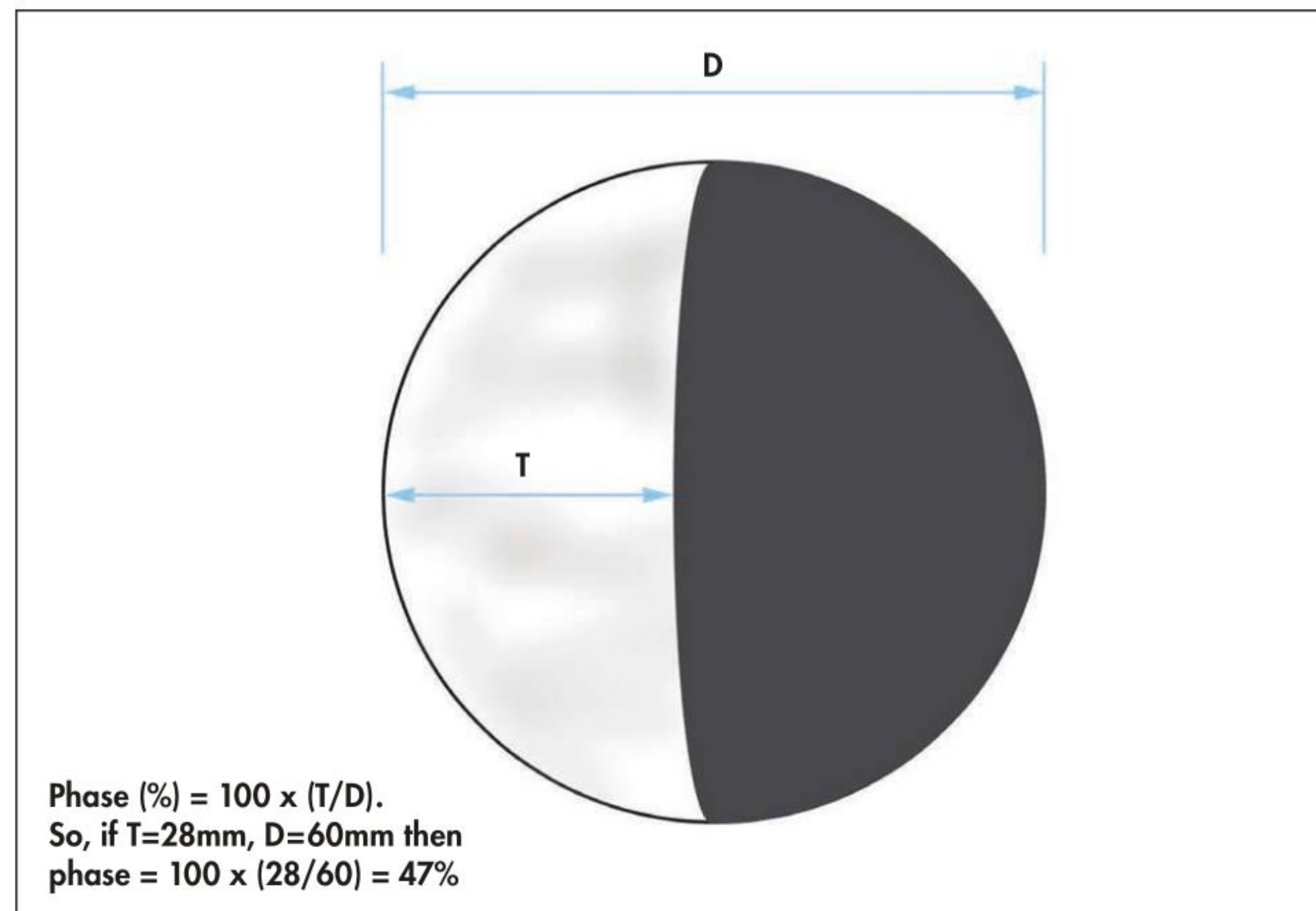
For a meteor to be a Perseid, its trail must track back to the radiant location which varies over time as shown in our graphic below. A Perseid close to the radiant typically appears short while those that occur some distance away appear long. Visually, during the peak period a single observer should expect to see 30-35 meteors per hour.



▲ The movement of the Perseid meteor shower's radiant from 15 July to 25 August

Venus at dichotomy

WHEN: 5-25 August



planet. It was first noticed by the German amateur astronomer Johann Schröter in 1793 and has been recorded fairly reliably ever since.

Observing the phase anomaly is fairly straightforward. It's best to start recording the phase of Venus as soon as possible to get used to the practice. Estimate what percentage of the disc the terminator crosses. The 50% phase will result in a terminator that appears perfectly straight as it runs from pole to pole.

A drawing or image can be used to estimate the phase. If drawing, use a circular blank and mark on it the shape of the terminator. Measure the distance from the centre of the bright limb through the centre line of the planet to the terminator. Divide this by the full diameter of the blank and multiply by 100 to give a phase percentage. Try measuring this through different filters. The phase anomaly is more pronounced through a blue filter than yellow or red one.

If you're making measurements over many days, it's important not to let previous days' values affect your judgement. Make your measurement as if you have no knowledge of what you recorded during previous sessions. This is, of course, easier said than done.

▲ Keep track of how the Schröter effect apparently distorts the progress of Venus's terminator



Venus reaches dichotomy on 15 August, a time when a view of the planet through the eyepiece of a telescope should show its disc as a 50%-lit semicircle. However, when Venus is in the evening sky it will typically reach its 50% phase two to four days earlier

than expected, while when it's in the morning sky, dichotomy typically occurs one to three days later than expected.

This irregular behaviour is known as the phase anomaly or Schröter effect and its cause is believed to be linked to the thick atmosphere that enshrouds the

Partial solar eclipse

WHEN: 1 August between 09:25 BST (08:25 UT) and 10:20 BST (09:20 UT)



A partial solar eclipse will take place on the morning of 11 August. In the UK the event is visible from the northern quarter of mainland Scotland, the northern quarter of Skye, the northern two thirds of the Outer Hebrides and Shetland. The eclipse magnitude increases the further north you go but even from Skaw close to the northern tip of Shetland, only 2.47% of the Sun's surface will be obscured by the Moon. Here the eclipse lasts 48 minutes starting at 09:27:33 BST (08:27:33 UT) and ending at 10:15:50 BST (09:15:50 UT).

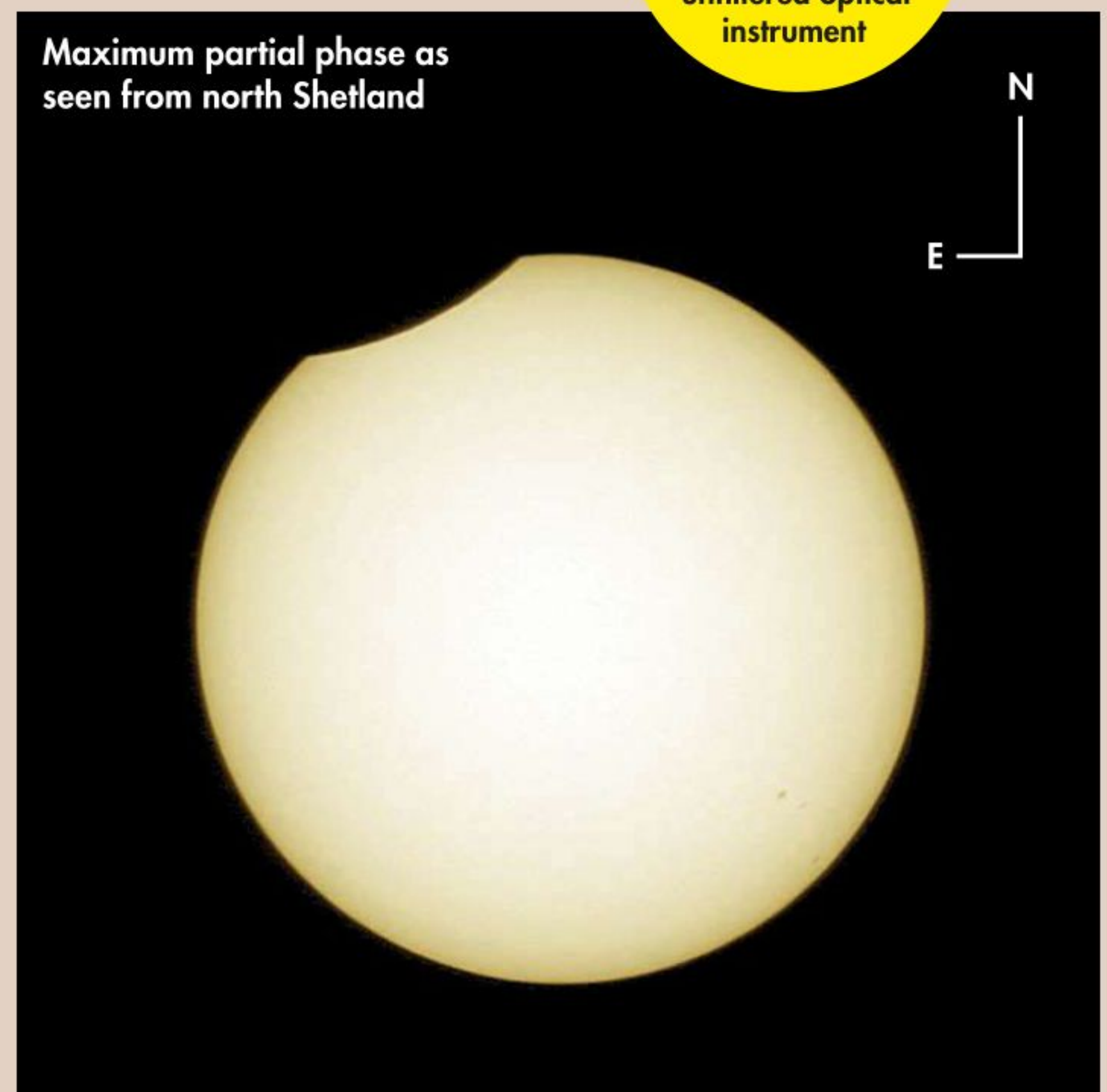
Further south of the viewing region, there's still hope if you

own an H-alpha telescope. The Sun's disc looks fractionally larger in H-alpha owing to 'spicules' which give the Sun's limb a fur-like appearance. In addition, a well-timed prominence extending off the Sun's disc around position angle 24° may allow you to spot the Moon passing in front of it even though none of the Sun's disc is covered. It's impossible to say how far south such an event could be seen because it depends on the precise position and size of any prominences. However, it's an interesting and unusual prospect which may extend the viewing area down perhaps as far as the line from Aberdeen to Fort William.

CAUTION

Never observe or image the Sun with the naked eye or any unfiltered optical instrument

Maximum partial phase as seen from north Shetland



THE PLANETS

PICK OF THE MONTH

Uranus

Best time to see: 31 August, 04:00 BST (03:00 UT)

Altitude: 48°

Location: Aries

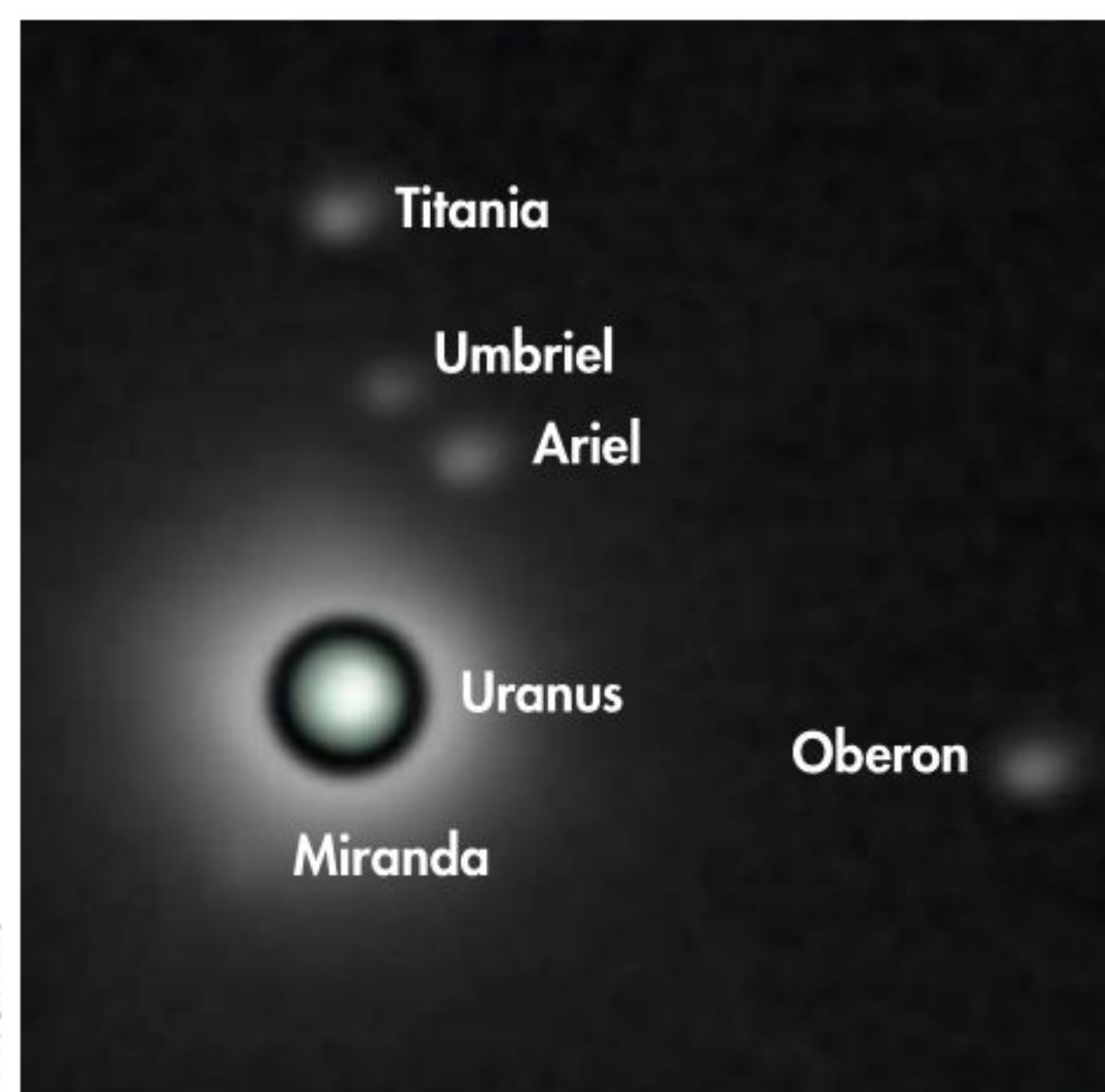
Direction: South

Features: Colour, bands, brighter moons

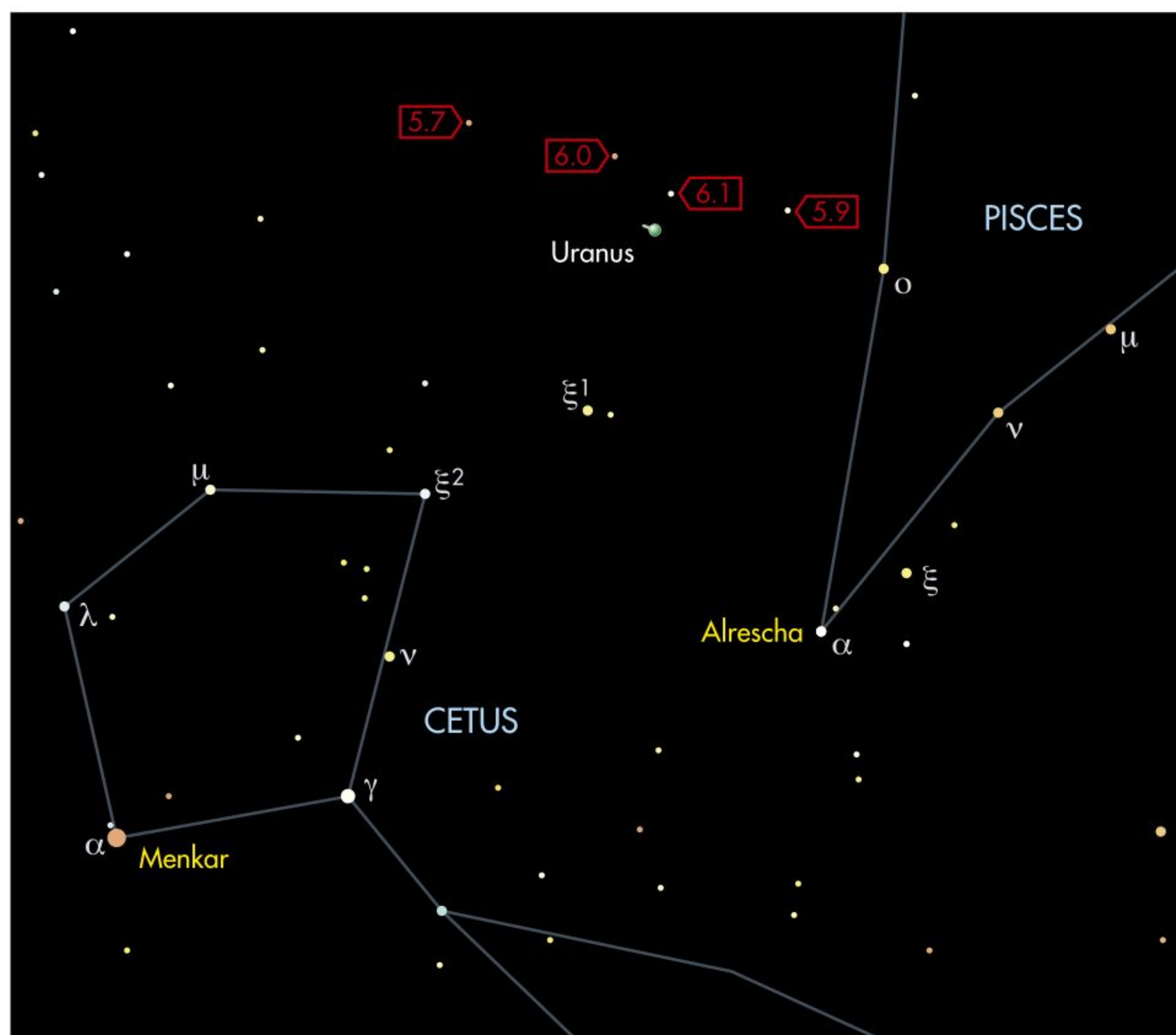
Equipment: 8-inch or larger

Uranus is moving into a good position for viewing this month. This distant world isn't normally listed as a mainstream planetary target because of its great distance and small disc size. However, it's the highest of the main outer planets as seen from the UK and as such merits more than just a quick glance.

At the start of the month, mag. +5.8 Uranus rises around 23:30 BST (22:30 UT) only managing to reach an altitude of



▲ Uranus and its five largest moons are all viable targets for amateur telescopes



▲ The position of Uranus during August (with the magnitudes of nearby stars marked)

28° in true darkness before astronomical dawn begins to light things up. However, by the end of August, Uranus just reaches its maximum UK altitude of 48° at the start of astronomical dawn.

Over recent years we've become accustomed to Uranus being positioned within Pisces, but this has now changed as the planet has slipped across the border into Aries. It will revisit its old haunt at the end of 2018, slipping once more back across the border before recommencing a more determined march east.

At mag. +5.8 Uranus is just about naked-eye visible from a dark site. It lies in a fairly blank area of sky slightly to the Alrescha (Alpha (α) Piscium) side of the

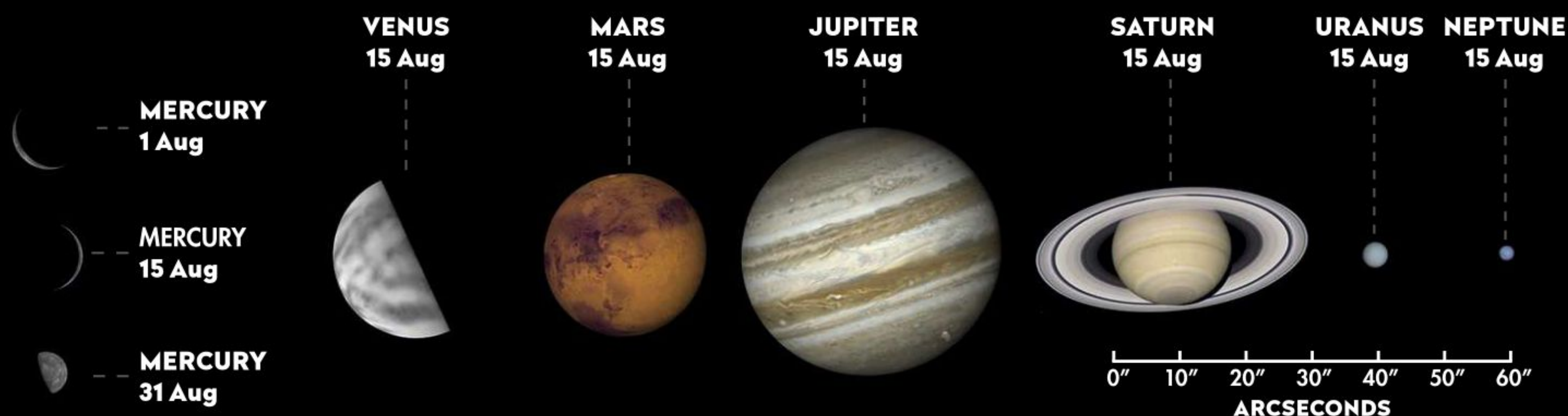
midpoint between Hamal (Alpha (α) Arietis) and Alrescha. There are a couple of stars here too which are fractionally dimmer than Uranus.

Through the eyepiece the planet's green hue is quite beautiful and it's obvious that it has a disc when using magnifications over 60x. The 3.6 arcsecond disc doesn't give up its secrets easily and high powers with large apertures are required to detect any atmospheric banding present.

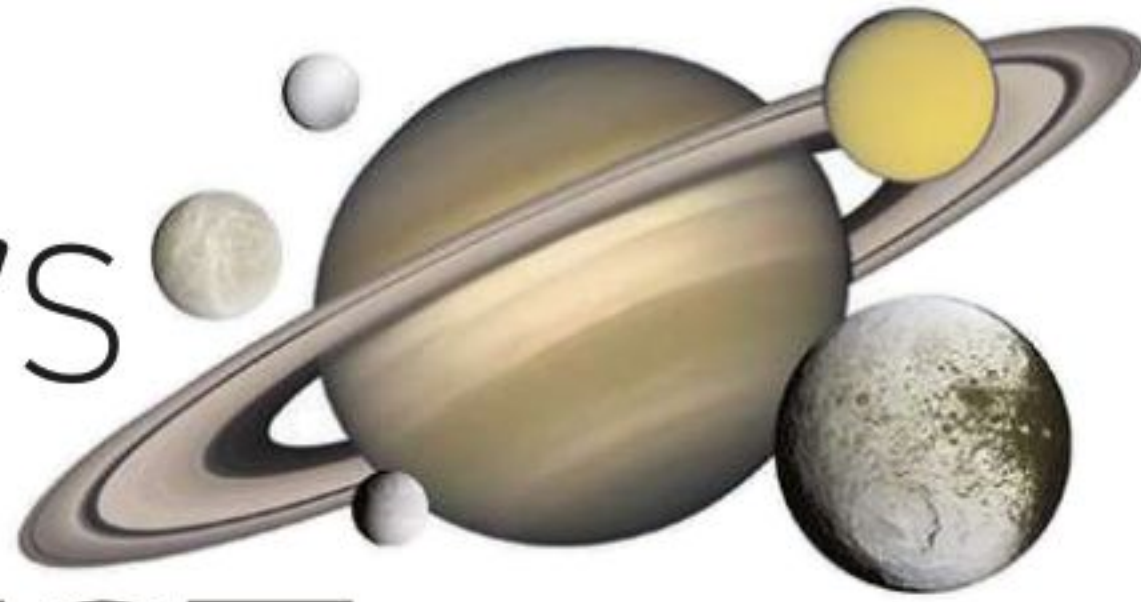
Steady seeing is essential for the best views and this is why Uranus's high altitude at the end of the month is so important. The higher the altitude, the steadier the view tends to be. So make the most of the opportunity.

THE PLANETS IN AUGUST

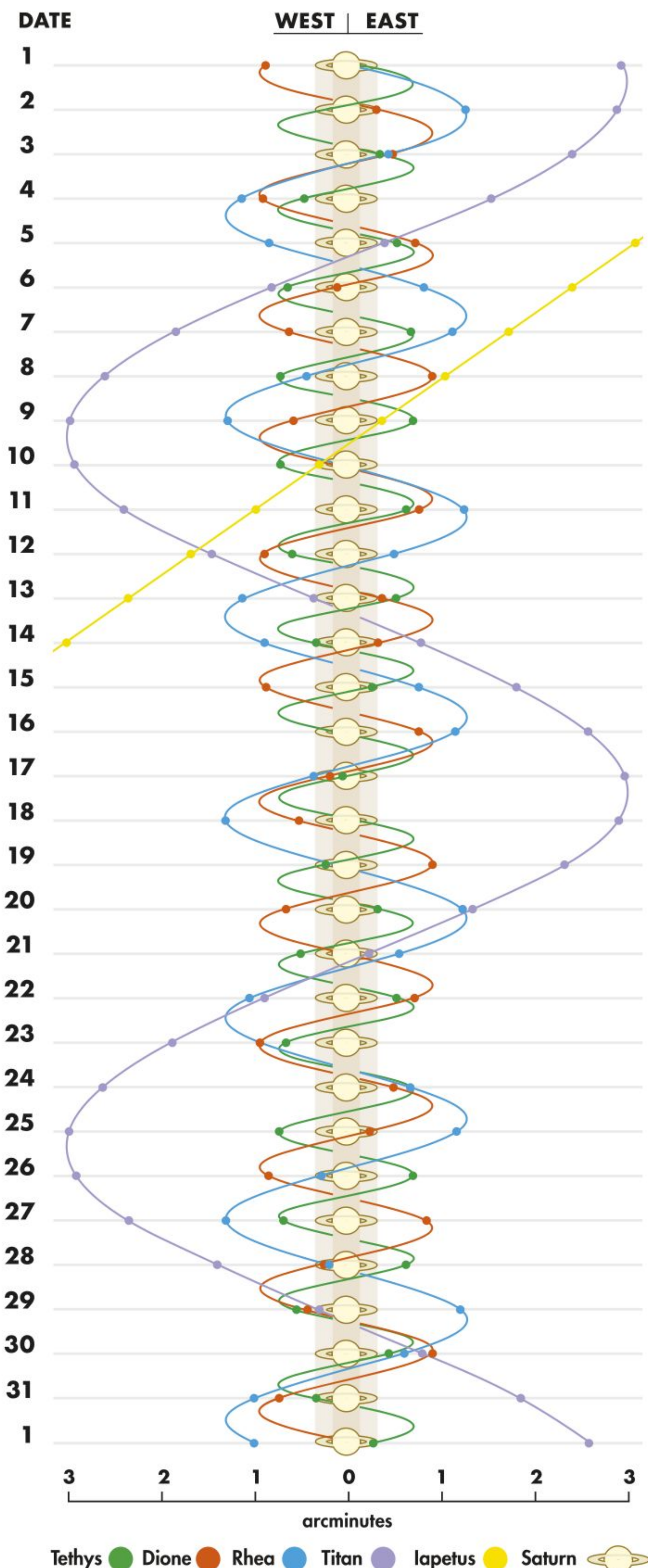
The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to match its orientation through a telescope



SATURN'S MOONS AUGUST



Using a small scope you'll be able to spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



Mercury

Best time to see: 26 August, 05:30 BST (04:30 UT)

Altitude: 8° (low)

Location: Cancer

Direction: East-northeast

Not visible at the start of the month, Mercury reaches inferior conjunction on 9 August and re-emerges into the morning sky after that. Greatest western elongation is on 26 August, when, low in the east-northeast, mag. +0.1 Mercury rises 100 minutes before the Sun for its best morning show of 2018. Post greatest elongation, Mercury brightens as it moves closer to the Sun. On 31 August, it shines at mag. -0.6.

Venus

Best time to see: 1 August, 20 minutes after sunset

Altitude: 9°

Location: Virgo

Direction: West

Venus reaches greatest eastern elongation on 17 August, with a solar separation of 45.9°. But the planet doesn't have much altitude post sunset, setting just over an hour after the Sun. At the start of August Venus presents a 20 arcsecond, 56%-lit disc and by 31 August it's 29 arcseconds across and 40% lit. The 50%-lit phase, or dichotomy, should occur on 15 August, though the Schröter effect may cause things to appear otherwise (see page 51). There's a lovely meeting of mag. -4.1 Venus and a 15%-lit waxing crescent Moon on the evening of 14 August.

Mars

Best time to see: 1 August, 01:00 BST (00:00 UT)

Altitude: 11°

Location: Capricornus

Direction: South

Mars is bright, telescopically large and frustratingly low for UK observers. At the start of August, mag. -2.8 Mars is low in Capricornus. Telescopically it shows a 24 arcsecond disc between 1-9 August, a good

size for seeing fine detail on the planet's surface as well as its poles. The southern pole is currently tilted towards Earth. Sadly, the planet only reaches 10° of altitude from the centre of the UK so fine detail will be lost through poor seeing.

Jupiter

Best time to see: 1 August, 22:00 BST (21:00 UT)

Altitude: 13°

Location: Libra

Direction: Southwest

Jupiter's brief observing window is closing with the planet significantly west of the central meridian as the sky darkens at the start of August. The almost first quarter Moon lies near mag. -1.9 Jupiter on the night of 17 August.

Saturn

Best time to see: 1 August, 22:45 BST (21:45 UT)

Altitude: 14°

Location: Sagittarius

Direction: South

Saturn is due south at the start of August. The mag. +0.6 planet lies north of the Teapot asterism in Sagittarius. A bright gibbous Moon jumps from the west to the east of the planet on the nights of 20-21 August. When the Moon is out of the way, look at Saturn with binoculars, placing it upper left-of-centre in the view. The beautiful Lagoon Nebula, M8, and Trifid Nebula, M20, will be right-of-centre. By 31 August the planet will have dimmed slightly to mag. +0.8.

Neptune

Best time to see: 31 August, 01:40 BST (00:40 UT)

Altitude: 30°

Location: Aquarius

Direction: South

The lengthening nights in August assist the visibility of Neptune which reaches its highest point in the sky, due south, in darkness from mid-month onwards. At mag. +7.9 you'll need at least a pair of binoculars to spot it.

YOUR BONUS CONTENT Planetary observing forms

THE NORTHERN HEMISPHERE IN AUGUST

KEY TO STAR CHARTS

- Arcturus
- STAR NAME
- PERSEUS
- CONSTELLATION NAME
-
- GALAXY
-
- OPEN CLUSTER
-
- GLOBULAR CLUSTER
-
- PLANETARY NEBULA
-
- DIFFUSE NEBULOSITY
-
- DOUBLE STAR
-
- VARIABLE STAR
-
- THE MOON, SHOWING PHASE
-
- COMET TRACK
-
- ASTEROID TRACK
-
- STAR-HOPPING PATH
-
- METEOR RADIANT
-
- ASTERISM
-
- PLANET
-
- QUASAR
- STAR BRIGHTNESS:
-
- MAG. 0 & BRIGHTER
-
- MAG. +1
-
- MAG. +2
-
- MAG. +3
-
- MAG. +4 & FAINTER



MILKY WAY

WHEN TO USE THIS CHART

- 1 AUGUST AT 01:00 BST
- 15 AUGUST AT 00:00 BST
- 31 AUGUST AT 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART



1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.

SUNRISE/SUNSET IN AUGUST*

DATE	SUNRISE	SUNSET
1 Aug 2018	05:26 BST	21:06 BST
11 Aug 2018	05:43 BST	20:47 BST
21 Aug 2018	06:00 BST	20:25 BST
31 Aug 2018	06:17 BST	20:02 BST

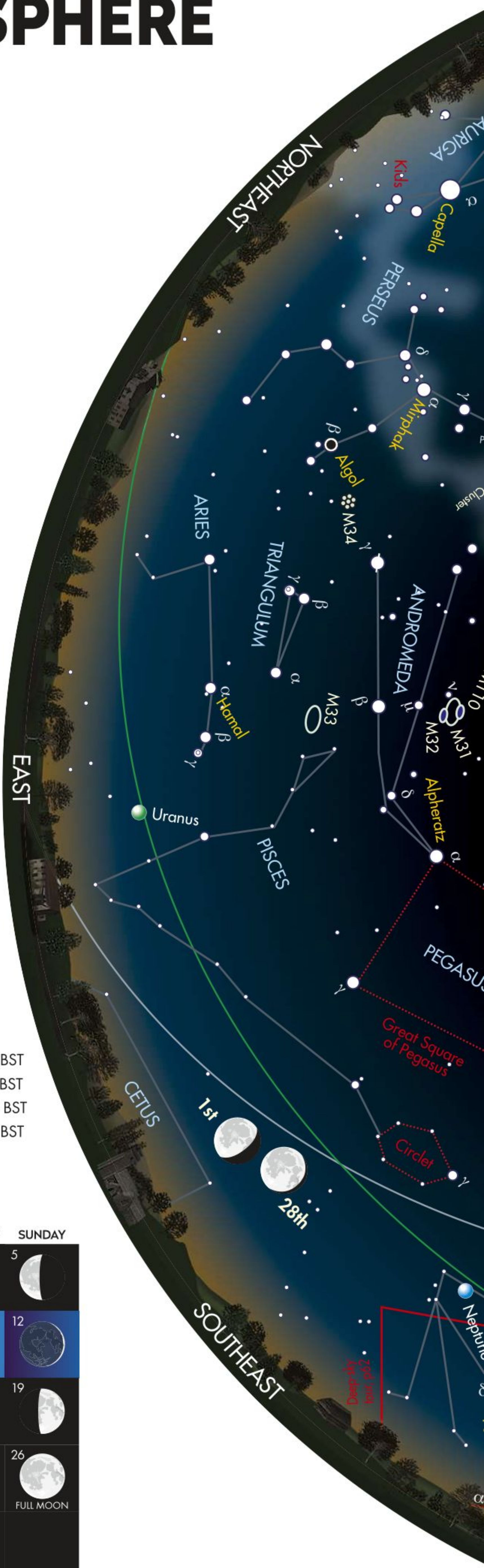
MOONRISE IN AUGUST*

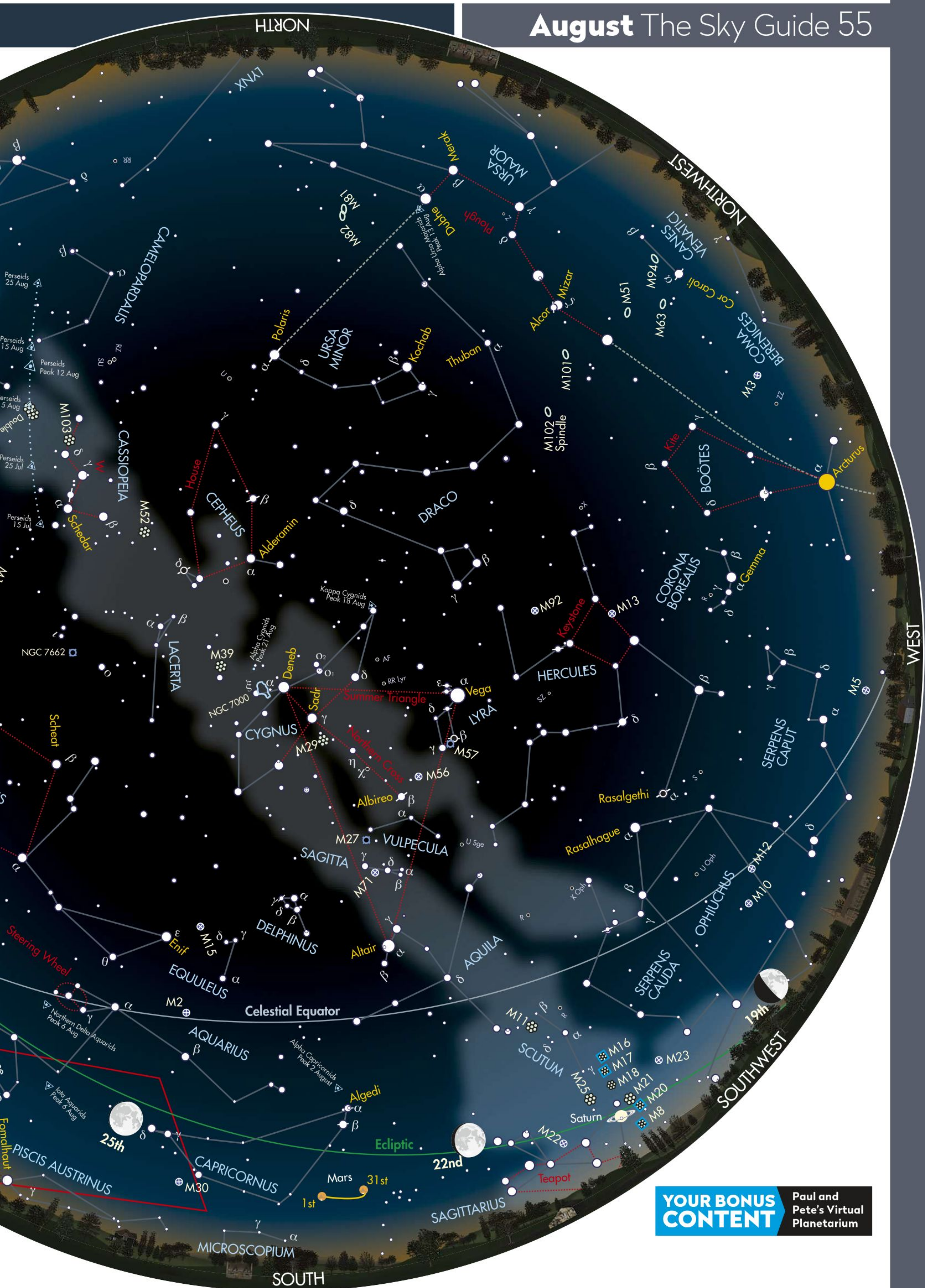
MOONRISE TIMES	
01 Aug 2018, 23:08 BST	17 Aug 2018, 13:27 BST
06 Aug 2018, 00:39 BST	21 Aug 2018, 17:40 BST
09 Aug 2018, 02:56 BST	25 Aug 2018, 20:09 BST
13 Aug 2018, 08:16 BST	29 Aug 2018, 21:33 BST

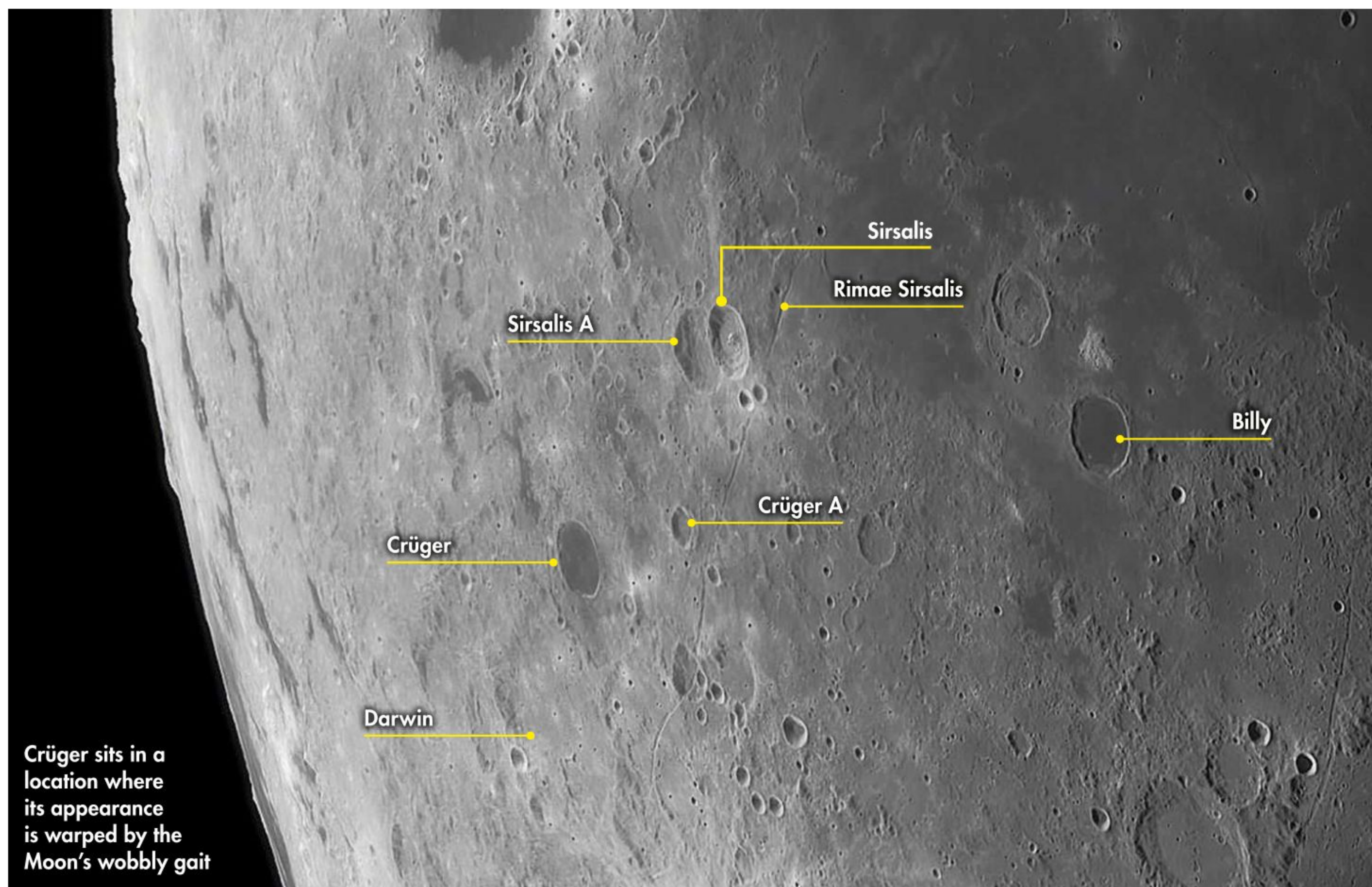
*Times correct for the centre of the UK

LUNAR PHASES IN AUGUST

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		







MOONWATCH

Crüger

Type: Crater

Diameter: 46km

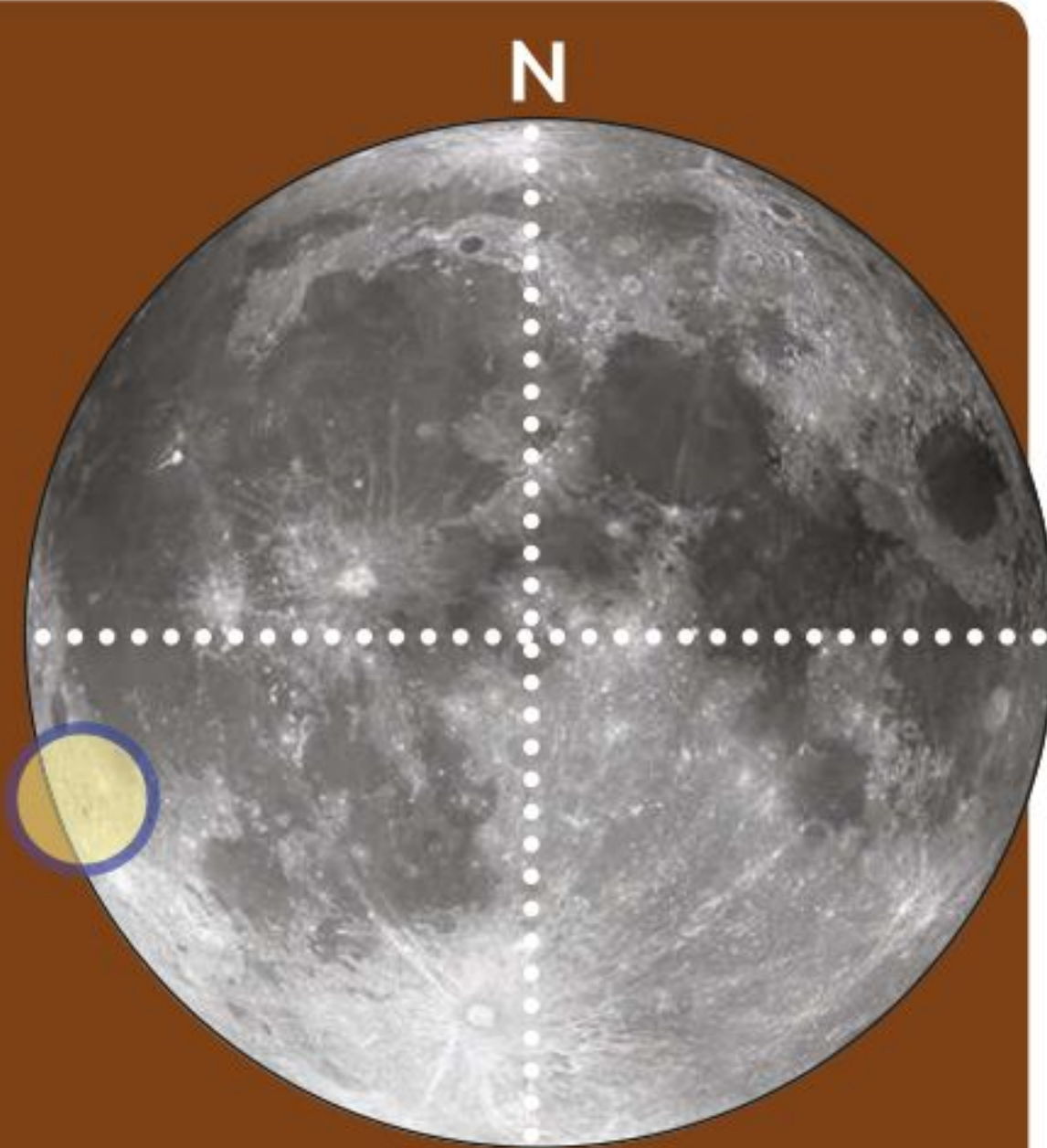
Longitude/latitude:

67° west, 16.7° south

Age: From 3.8-3.85 billion years old

Best time to see: Six days after first quarter (24-26 August) or five days after last quarter (8-9 August)

Minimum equipment: 2-inch refractor



The 46km crater **Crüger** is positioned close to the Moon's western limb, so best seen just before full Moon or when the Moon's a thin, waning crescent. Being so close to the Moon's edge Crüger's appearance is at the mercy of lunar libration – the way the Moon appears to wobble as seen from Earth. This happens because the Moon's orbit is both elliptical and tilted to our own. The tilt allows us to peek further around the northern or southern limb from time to

time, while the elliptical nature of the Moon's orbit causes it to speed up and slow down, giving us the chance to peek around the eastern and western limbs.

Taken together, this complex motion allows us to see up to 59% of the Moon's surface from Earth. The appearance of any feature close to a lunar limb is dramatically affected by the libration state. Although circular, to us Crüger is foreshortened into an ellipse and it's the narrowness of the ellipse which is affected by the

“So close to the Moon's edge, Crüger is at the mercy of lunar libration”

libration. As luck would have it, the crater **Billy**, 485km to the east of Crüger, has the same 46km diameter and a similar dark-floored appearance. This gives us an opportunity to compare both features to see how much more dramatic the foreshortening effect is on a crater closer to the limb.

In many ways Crüger appears like a half-sized version of the crater Plato on the northern border of Mare Imbrium. However, location is everything on the Moon and where Plato stands out because of its proximity to the vast dark expanse of the Imbrium Basin, Crüger is somewhat lost in its heavily cratered surroundings. This is despite it having one of the lowest albedo values on the Moon's surface. Albedo is a figure indicating the amount of incident light reflected back from a surface. The reason Crüger is so dark is that its

floor has been resurfaced with basaltic lava and there have been relatively few nearby impacts that may otherwise have deposited bright ejecta over the crater's floor.

Crüger's floor is mostly featureless apart from a tiny, 2.5km diameter craterlet right in its centre. Trying to resolve it makes for an interesting challenge that would best suit high resolution imaging setups.

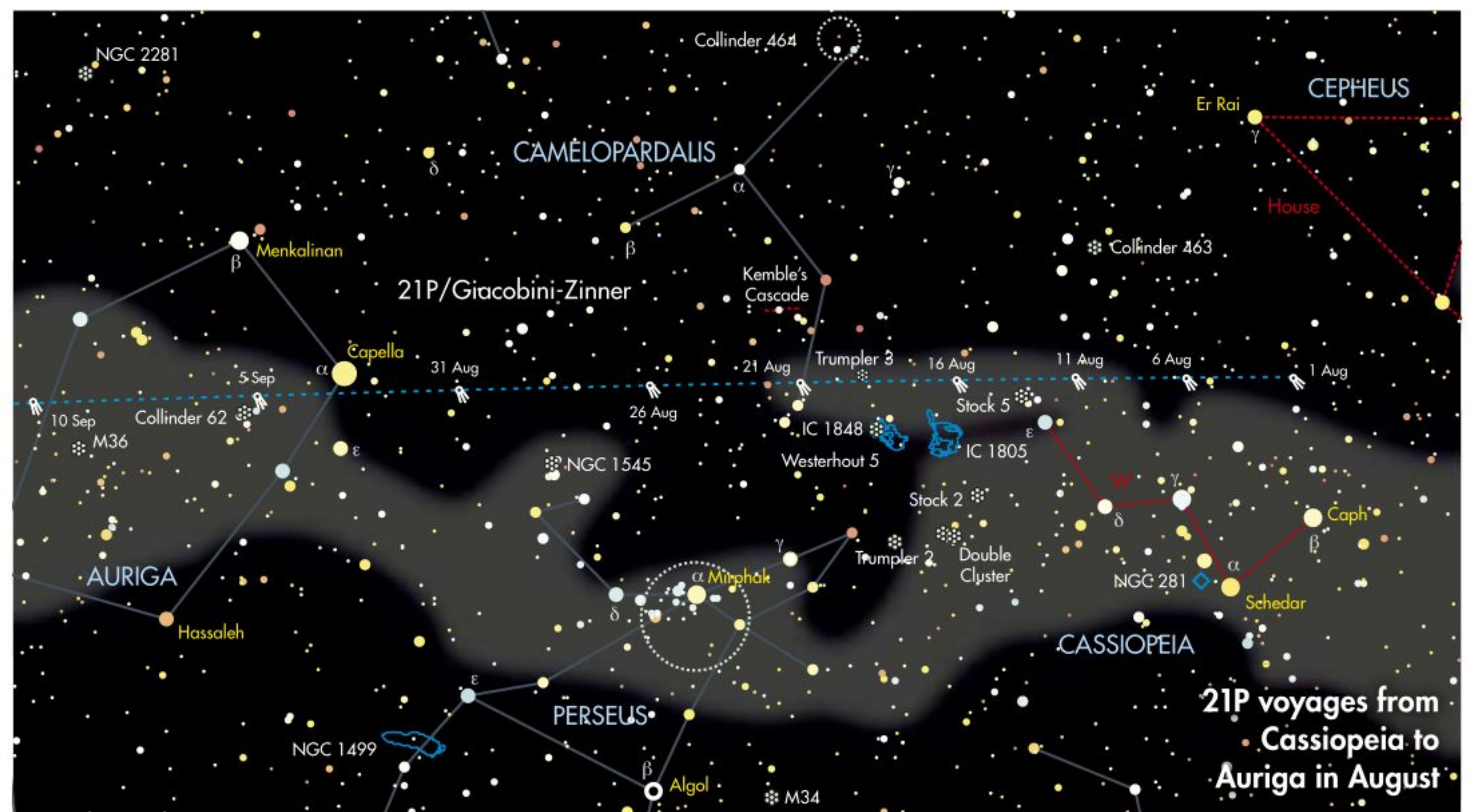
Located 125km to the east of Crüger is **Crüger A**, a 27km diameter crater next to a rille named **Rimae Sirsalis**, which is 426km long but averages only 3km wide. It stretches from the Oceanus Procellarum in the north down to the huge 131km diameter feature **Darwin** to the south of Crüger. **Sirsalis** is the eastern and uninterrupted crater of a pair of craters 200km to the northeast of Crüger. It overlaps 42km **Sirsalis A** immediately to its west.

COMETS AND **ASTEROIDS**

The epic journey of 21P/Giacobini-Zinner reaches its brightest leg for observers on Earth

Comet 21P/Giacobini-Zinner has been brightening over previous months and is now within easy reach of binoculars. At the start of August it will appear at mag. +8.8, nestled between the constellations of Cassiopeia and Cepheus. From there it tracks east, brightening as it goes. It leaves Cassiopeia on 19 August, slipping across the border into the indistinct Camelopardalis. It passes south of the lovely asterism known as Kemble's Cascade between 21-23 August before ending the month in Auriga. By 21 August, the comet will have brightened to mag. +7.2 though the rate of brightening slows at the start of September with the comet reaching a peak of mag. +7.0 from 8-13 September.

21P/Giacobini-Zinner is a periodic comet originally discovered by Michel Giacobini at the Nice Observatory in 1900. It was subsequently



recovered by Ernst Zinner two orbits later. The comet has an orbital period of 6.6 years and will next reach perihelion on 10 September 2018. The central nucleus is believed to be around 2km in diameter.

This comet is the parent body for the Draconid meteor shower

which is active between 6-10 October. The shower has a typical ZHR (see page 50) of 10 meteors per hour but has shown brief storm-level activity in the past. This year there are predictions for ZHRs in the range of 20-50 meteors per hour as, just after midnight on

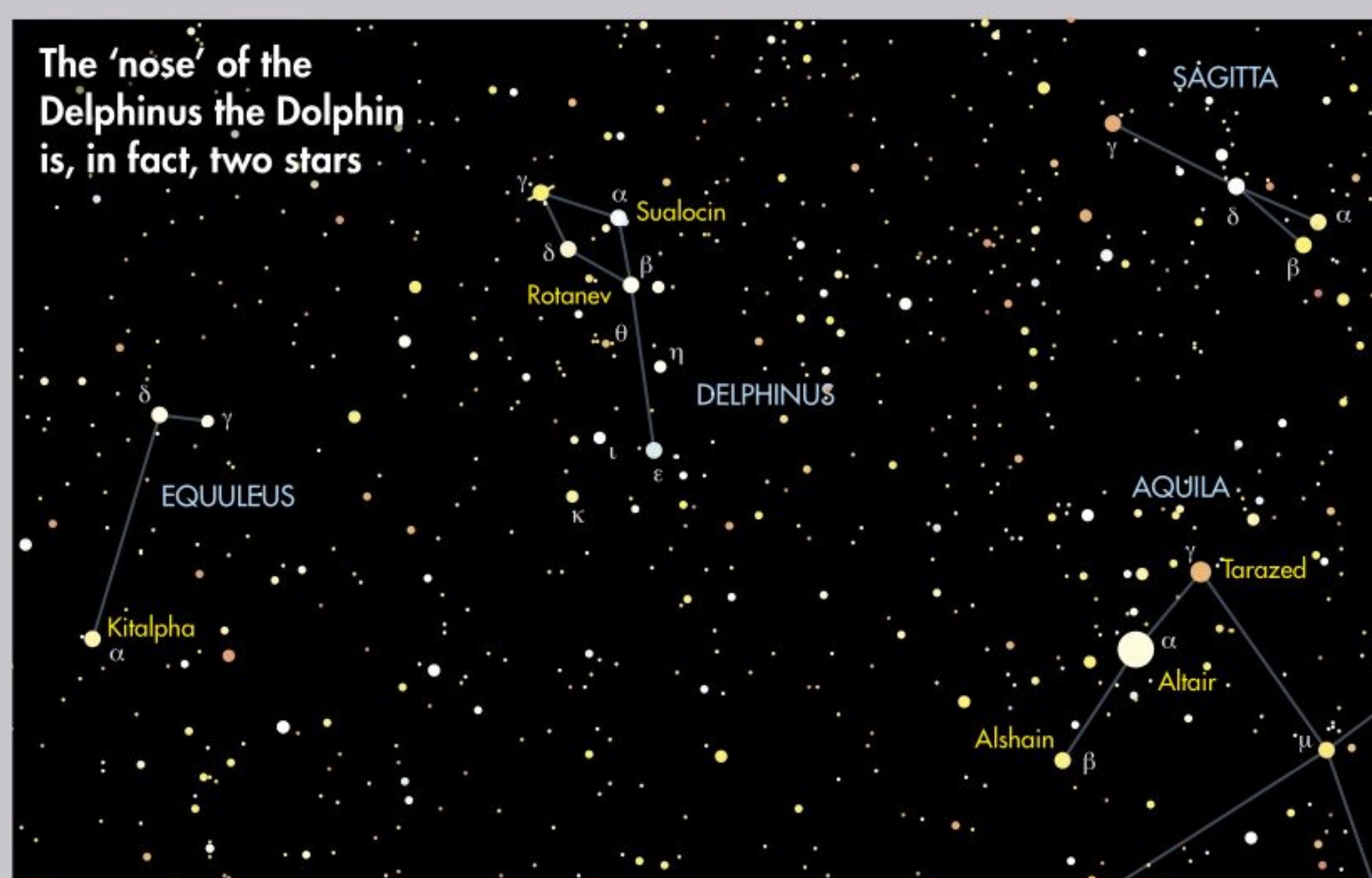
9 October, we pass through the dust trail left by comet Giacobini-Zinner in 1900. Draconid meteors are exceptionally slow moving with an entry velocity of 21km/s. In comparison, the Perseids have an entry speed of 59km/s and the Geminids average 35km/s.

STAR OF THE MONTH

Double star Gamma (γ) Delphini performs an intriguing colour-changing trick

The constellation of Delphinus the Dolphin is a small but distinctive pattern of stars visible to the east – or left from the UK – of the giant Summer Triangle asterism. It looks like a diamond with a short tail and in mythology is supposed to represent the head of a bottlenose dolphin, the diamond depicting the creature's nose and the short tail the start of its neck. The tip of the nose is marked by Gamma (γ) Delphini, a beautiful double star.

Its components are of magnitudes +5.1 and +4.3, which combine to appear at mag. +3.9 to the naked eye. They have spectral classifications of F7 and K1 respectively, which



means they should appear white and yellow-orange. However, with a separation of just 9.2 arcseconds, the colours contrast to create the illusion of additional colour within the fainter white star. Reports of it

looking yellow, green, blue and orange are not unheard of.

The stars are physically 2.5 and 7.5 times larger than our Sun and are a true binary pair. Their orbit is highly eccentric, bringing them as

close together as 40 AU and as far apart as 600 AU. The orbital period is 3,200 years. The brighter yellow orange component, Gamma-2, is in the process of becoming a giant star as it begins to fuse helium. The Gamma Delphini system lies 104 lightyears from the Sun and is around two billion years old.

You don't need a large telescope to enjoy Gamma Delphini and it splits well even at around 50x power. So the next opportunity you get, go outside and make a note of the colour of the fainter, western component. An interesting experiment would be to see if the colour appears to change when you use different apertures and magnification.

**STEPHEN TONKIN'S****BINOCULAR TOUR**

There are plenty of colourful stars and fuzzy galaxies around Cassiopeia and Andromeda

☑ Tick the box when you've seen each one

1 M31

10x 50 Use the arrowhead formed by Caph (Beta (β)), Shedar (Alpha (α)) and Gamma (γ) Cassiopeiae to point you to Mirach (Beta (β) Andromedae), 22° to the south-southwest. Place Mirach at the bottom of the field of view and find Mu (μ) Andromedae near the top. Now place that at the bottom and the elliptical shape of M31, the Andromeda Galaxy, will appear near the top. Note the bright glow of its nucleus and see if you can identify the two companion galaxies, M32 (below) and M110 (above), which appear as fuzzy stars. ☐ **SEEN IT**

2 35 CAS

10x 50 If Segin (Epsilon (ε)), Ruchbah (Delta (δ)) and Gamma (γ) Cassiopeiae form three vertices of a rhombus, then surrounding the fourth is an isosceles triangle of 6th magnitude stars covering around one square degree of sky. Nearest Segin is mag. +6.3 35 Cassiopeiae. Its mag. +8.4 companion is a very easy split in

10x50 binoculars, nearly an arcminute to the north. The brighter of the pair is very white, but see if you can detect any colour in the companion. This is a line-of-sight pairing, not a true binary star. ☐ **SEEN IT**

3 TV CAS

10x 50 This one's a true binary though you won't be able to see the fainter companion. You'll find mag. +7.2 TV Cassiopeiae 1.25° east of Caph. It's an eclipsing binary with a period of 1.81 days, when its brightness falls by a magnitude then rises again to its usual brightness during a nine-hour eclipse. If you're new to variable star observing, TV Cas is a good starter star because it's circumpolar, so it's always above the horizon, and its period means you can see an eclipse every week or so. ☐ **SEEN IT**

4 CAROLINE'S ROSE

15x 70 Our next object was discovered in 1783 by Caroline Herschel. Caroline's Rose (NGC 7789) is 6° due west of Shedar, between Rho (ρ) and Sigma (σ) Cassiopeiae. Although

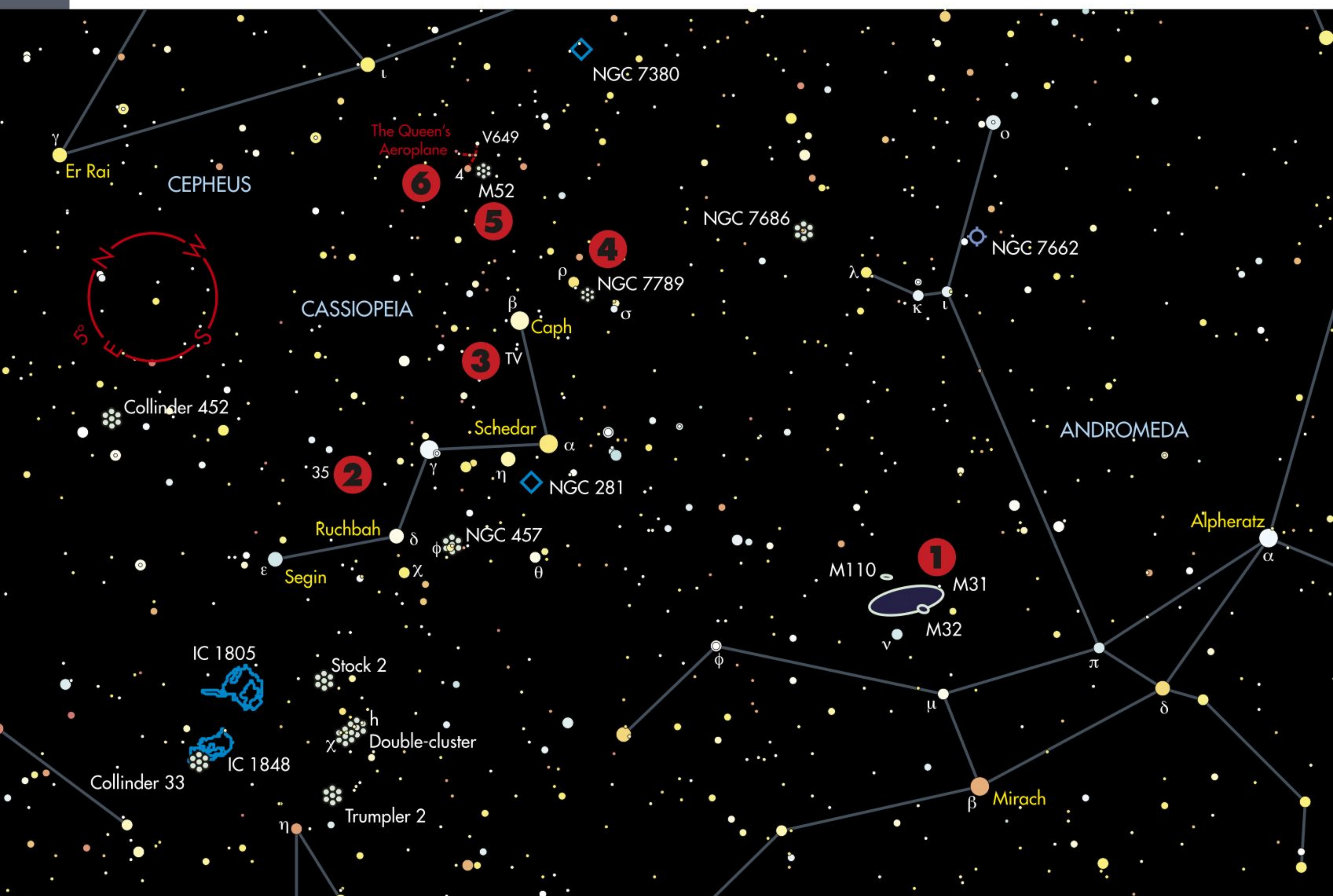
it's an open cluster, don't expect to be able to resolve any stars using averted vision. Even in 15x70 binoculars it appears as a soft glow, about half the apparent diameter of the Moon. Aged about a billion years, Caroline's Rose is unusually old for an open cluster and many of its stars have become red giants. ☐ **SEEN IT**

5 M52

15x 70 The 7th magnitude open cluster M52 is in a straight line with Shedar and Caph, 6° beyond Caph. It appears as about 10 resolved stars, the brightest of which is a mag. +8.3 one on the western side, against a grainy glow in the form of an arrow-head 13 arcminutes long. The grainy glow itself, which is clearly distinct from the Milky Way stars, is created by nearly 1,000 stars. It is 4,600 lightyears away and extends over about 18 lightyears. Charles Messier discovered it by chance in 1774, when a comet passed nearby. ☐ **SEEN IT**

6 QUEEN'S AEROPLANE

10x 50 To the left of M52 lies the golden yellow mag. +5.0 4 Cassiopeiae. This marks the starboard wing tip of the Queen's Aeroplane asterism in which eight stars shine at mag. +8.0 or brighter. The other wing tip, a degree west, is the mag. +6.6 blue-white V649 Cas. The 'fuselage' extends to a mag. +6.7 orange-red star, nearly a degree to the north. Dark skies will enhance this little party of colour. ☐ **SEEN IT**



THE SKY GUIDE CHALLENGE

How to spot celestial bodies (other than the Moon) while the Sun's still up



▲ The Moon can be a useful guide for 'hopping' to a planet during the day

It's perfectly possible to observe the Moon, some planets and even bright stars during the day as long as you know how to find them. When light from the Sun passes through our atmosphere the shorter blue wavelengths are affected most. They are scattered so that for us on the ground it appears that blue light is coming from all directions. The blue hue that the sky takes on is like a light barrier because the sky itself is luminous, shining with the brightness of all that blue light spread around it. As a result, when you look at an object through it, the contrast will be badly affected and the object will appear faint.

Venus fares pretty well in this respect. It's a really bright planet that you can pick out in the daytime sky without any optical aid, just experienced eyes. You can also see Mercury and Jupiter in daytime, though you'll need binoculars or a telescope to do so. Saturn is also possible but it requires a

really clear sky to detect its super-faint appearance.

Mars is the awkward one because it only really becomes very bright when it's close to opposition. At such times it's difficult to see in daylight because it is lodged firmly in the dark of night. When it does move into the daylight sky, it

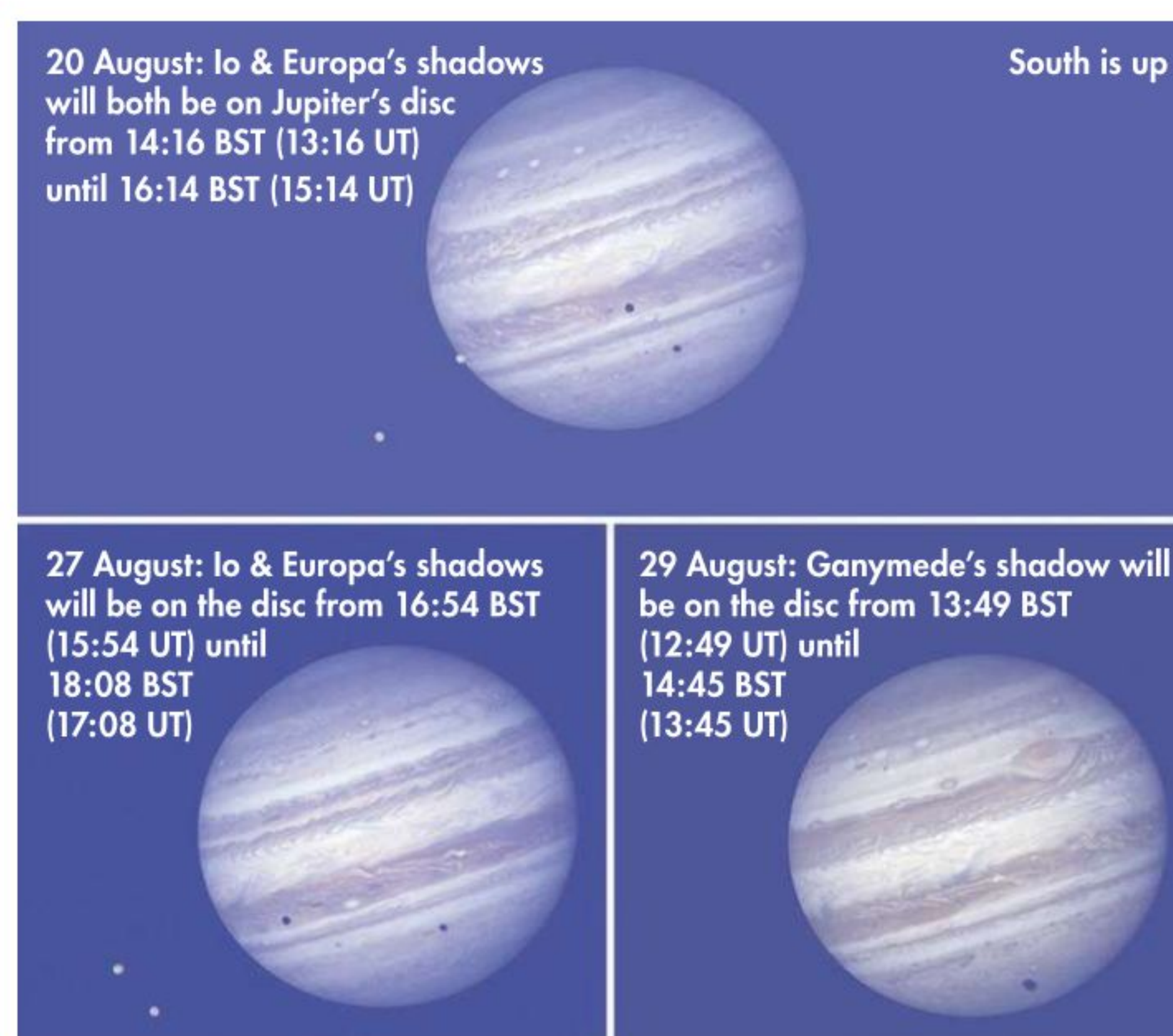
loses some of its brilliance and becomes difficult to see.

The presence of the Sun is a concern for daylight planet spotting and care must always be taken not to look directly at it with the naked eye or any unfiltered optical instruments. Placing yourself in the shadow of a building is a good

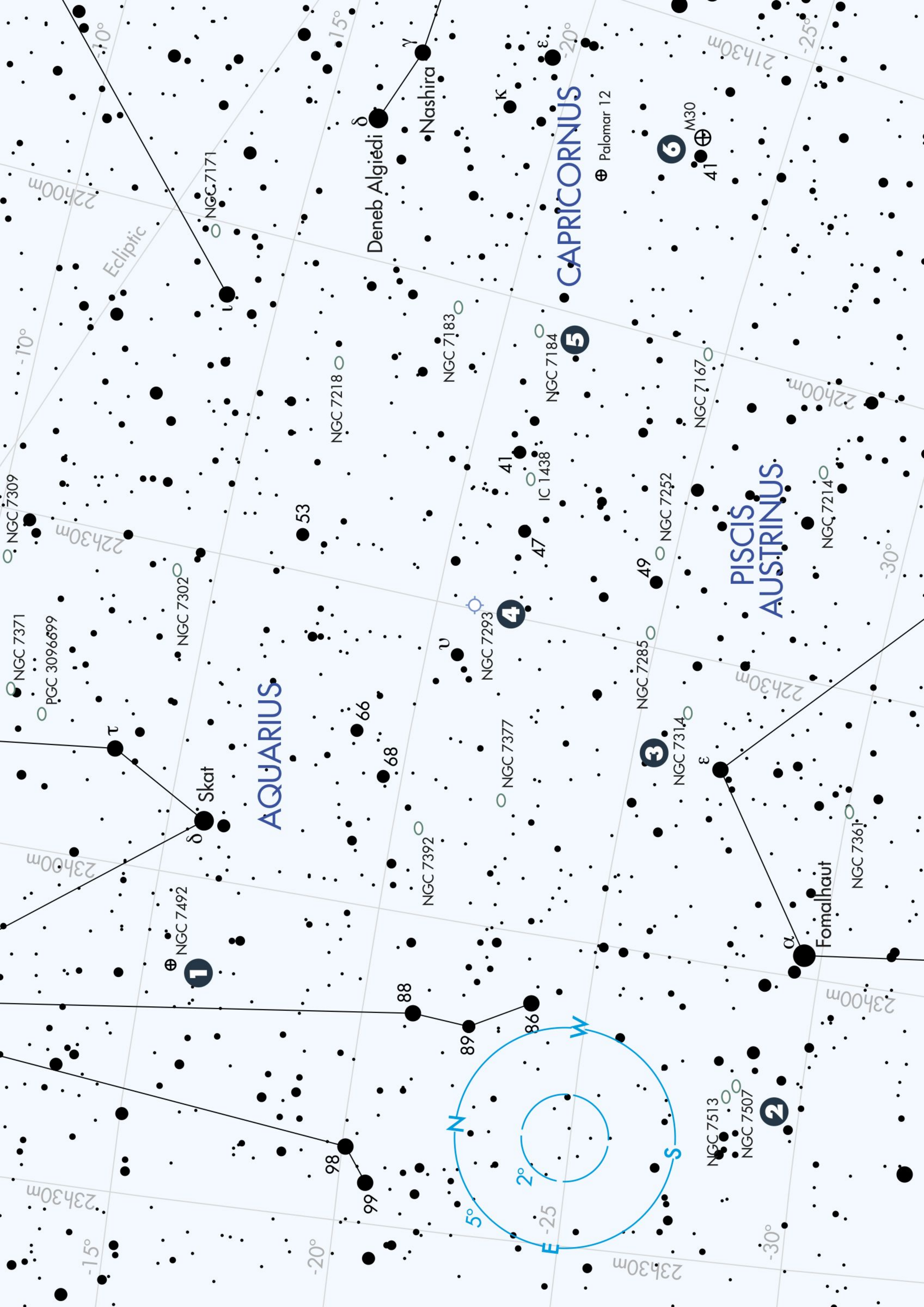
precaution, but vigilance is still required.

Locating a planet in a blue sky can be tricky because of a lack of navigational guides. The Sun is an obvious assistant and can be used as long as your scope is fully white light filtered and its finder is capped. The best method is to fit the white light filter, focus and centre-up on the Sun's disc. Look up the Sun's current RA and Dec. Set your telescope mount's setting circles to match these figures then look up the RA and Dec. of your target planet. Slew the telescope so that the RA and Dec. match the planet's values. Make doubly sure the telescope is looking away from the Sun then remove the white light filter and uncap the finder. Using the finder, try and identify the planet.

For an added challenge this month there are a number of daytime Galilean moon shadow transits on Jupiter's disc which should be visible in clear skies when the Sun is up.



▲ Three shadow transit events, which may be visible in clear daylight

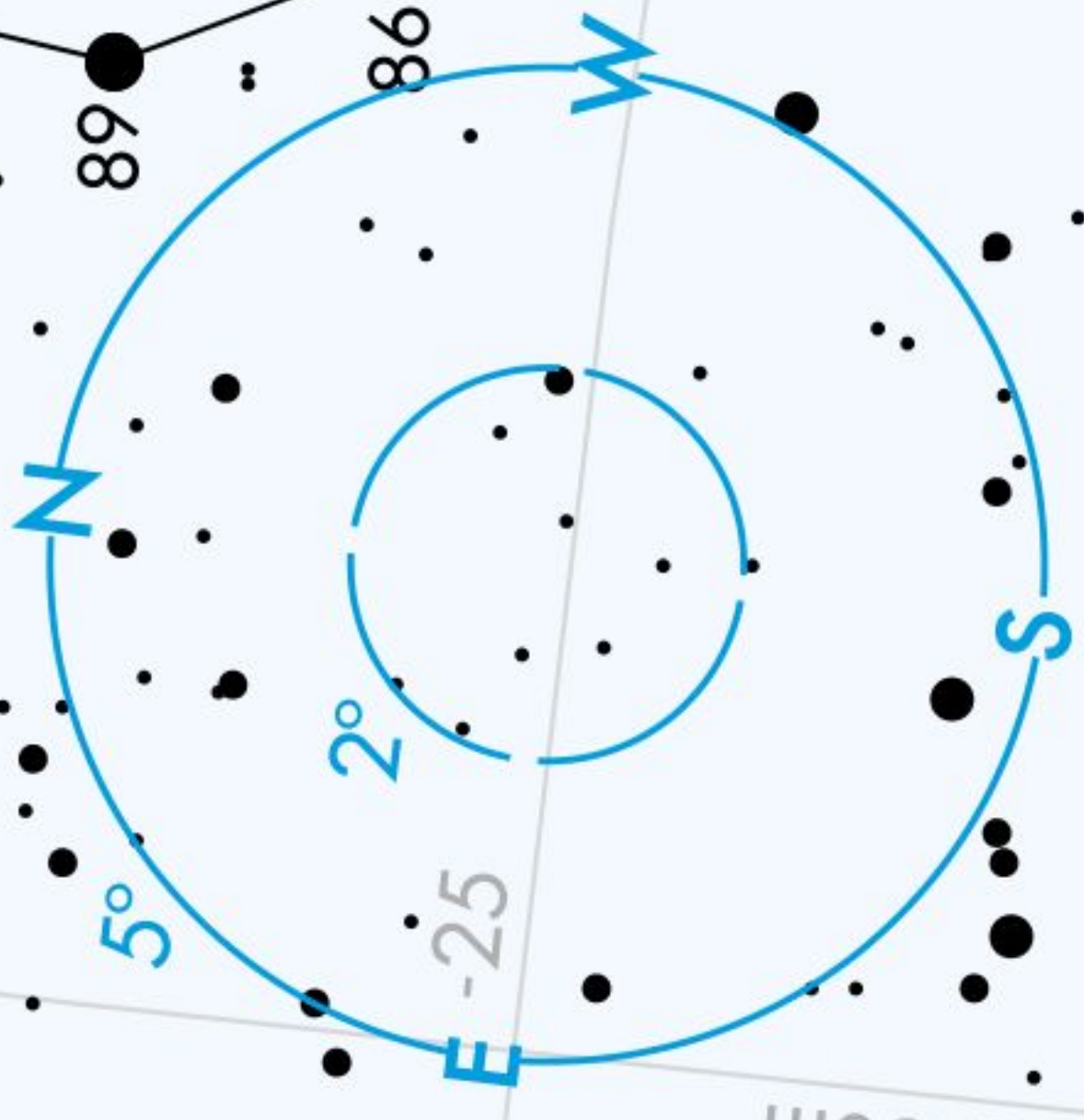


AQUARIUS

CAPRICORNUS

PISCIS AUSTRINUS

Ecliptic



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Deneb Algiedi

Nashira

Palomar 12

Fomalhaut

NGC 7492

NGC 7302

NGC 7171

NGC 7218

NGC 7183

NGC 7184

NGC 7167

NGC 7214

NGC 7361

NGC 7392

NGC 7293

NGC 7377

NGC 7285

NGC 7314

NGC 7513

NGC 7507

NGC 7309

PGC 3096699

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DEEP-SKY TOUR

Fancy a dip? Let's look at some of the sights in the area known as the Sea

☑ Tick the box when you've seen each one

1 NGC 7492



 This month's Deep-Sky Tour takes place in an area of sky affectionately known as 'the Sea' for the simple reason that it contains an awful lot of watery-themed constellations. These include: Pisces, the Fishes; Pisces Austrinus, the Southern Fish; Cetus, the Whale; Capricornus, the Sea Goat; and Aquarius, the Water Bearer (Delphinus, the Dolphin is a little way off to the north looking like it made a wrong turn and got lost at some point).

Our first target is the mag. +11.5 globular cluster NGC 7492, 3.3° east and slightly north of mag. +3.3 Skat (Delta (δ) Aquarii). This has a very low surface brightness and is challenging for anything smaller than 10 inches in diameter. It looks similar to an irregular comet nucleus at low to mid powers, and, at higher powers, like a circular glow loosely scattered with glittering diamonds. This is a distant object, discovered in 1786 by the venerable William Herschel, estimated to be 110,000 lightyears away. ☐ **SEEN IT**



2 NGC 7507

  Our next target is even more distant. Galaxy NGC 7507 is located 72 million lightyears away in the low southern constellation of Sculptor. It lies 3.1° east and 1.2° north of Fomalhaut (Alpha (α) Piscis Austrini), the most southerly 1st magnitude star visible from the UK. The galaxy shines at mag. +10.5 and its visibility is hindered by low altitude from the UK. Smaller apertures show it 6 arcminutes northwest of a 10th magnitude star, appearing like a concentrated circular patch 30 arcseconds across with a star-like nucleus. The galaxy appears larger with increased aperture and eventually its outer halo appears elongated. The 10 arcsecond central core has a star-like point in its centre. ☐ **SEEN IT**

3 NGC 7314

  Next up is the spiral galaxy NGC 7314, listed at mag. +11.9. This is another low object for UK skies, being located in Piscis Austrinus, 1° north and 1° west of the mag. +4.2 star Epsilon (ε) Piscis Austrini. The galaxy appears as a relatively small object but despite its faint magnitude, it should just about be visible in a 6-inch telescope as a faintly glowing 2x1 arcminute smudge. Larger apertures should start to show a mottled elongated core region surrounded by a misty outer halo. The elongated appearance of the core seems to be slightly tilted out of alignment to the main axis of the outer halo glow. ☐ **SEEN IT**

4 NGC 7293

  Only 700 lightyears away, NGC 7293, the Helix Nebula, is the

◀ NGC 7293, the Helix Nebula: two overlapping rings of light surrounding a mag. +13.5 central star


THIS DEEP-SKY TOUR HAS BEEN AUTOMATED

ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.





nearest and brightest planetary nebula. On paper its mag. +7.3 listing looks promising, but a 14x11 arcminute apparent size means its surface brightness is low. It's relatively easy to see through binoculars but a telescope using medium power looks straight through it! Low to medium powers work best as does the use of averted vision, or a UHC or OIII filter. Scopes over 10 inches show two overlapping rings of light surrounding a mag. +13.5 central star. Imagine mag. +3.3 Delta (δ) Aquarii and mag. +3.7 88 Aquarii as the endpoints of one side of an isosceles triangle. Mag. +5.2 Upsilon (υ) Aquarii sits at the other vertex with the Helix 1.2° west and fractionally south of Upsilon. ☐ **SEEN IT**

5 NGC 7184

 Head 6° to the west of the Helix Nebula to locate our penultimate object, the spiral galaxy NGC 7184. This is located in Aquarius, not very far from the constellation's border with neighbouring Capricornus. NGC 7184 is a large and relatively bright galaxy, listed at mag. +11.2 with an overall apparent size of 5.8x1.8 arcminutes. A 10-inch scope reveals a circular core surrounded by an elongated halo with an overall size of 4.5x1.5 arcminutes. Larger apertures reveal the fainter outer regions of the halo. The core begins to look uneven through large apertures, varying in brightness and shape. It appears slightly oval with the northwest side appearing brightest. ☐ **SEEN IT**

6 M30

  Our final object is globular cluster M30 in Capricornus – still technically part of 'the Sea' as the constellation represents a goat with a fish tail! M30 lies 23 arcminutes west of mag. +5.2 41 Capricorni and has a listed magnitude of +7.7, subtending a total apparent size of 11 arcminutes. A 6-inch telescope shows the central 3.5 arcminutes as a fuzzy glow with irregular edges. Using a high power helps resolve some cluster stars. A 10-inch scope expands M30's size to 5-6 arcminutes and magnifications of 150-200x resolve much of the cluster. Larger apertures show M30 is elongated east-west with a number of star-strings emanating from its core. Two prominent examples radiate from the core in a north and northwest direction. ☐ **SEEN IT**

YOUR BONUS CONTENT

Print out this chart and take an automated Go-To tour

ASTROPHOTOGRAPHY



Longer trails like this one are more likely to occur further from the meteor shower's radiant

slowly drifting across the field of view. It's often advised to point your camera approximately 60° from the radiant because the trails will appear longer. Adjacent to the radiant, meteors appear to be coming almost directly at you and their trails will be short. At the end of the day, it's down to personal preference, but having the radiant in frame will show how the trails appear to originate from a single area. If you're using a fixed platform it can be interesting to let the radiant move across the top or bottom of frame, giving you a good area of sky away from the radiant for longer trails while still retaining the perspective source of the shower. You can also position the radiant so that it sits in one corner of the frame to achieve the same effect. However, here it's important to make sure that the tracking motion over the course of the night doesn't move a foreground object, such as a building or a tree, into frame. Meteor photography is a statistical game and you need to make sure your imaging frame is as full of sky as possible to maximise your chances of catching a trail.

Using a tracking mount allows you to compose any frames that contain trails into a single image. This can produce a dramatic effect, showing just how the trails all appear to point back to the radiant. The variation in trail length, with longer trails appearing further from the radiant and shorter ones occurring close to it, really helps enhance the 3D nature of the shower in the atmosphere.

Although an August night isn't normally that cold, there can be a fair bit of moisture in the air. This has a tendency to make its presence known by condensing on the camera lens. It's important to keep checking for this at regular intervals throughout the night by shining a torch onto the lens surface. If the lens has become opaque the moisture can be removed by the gentle application of hot air from a 12V camping hairdryer.

Perhaps the most important skill to master is patience. It can be frustrating to sift through thousands of images only to find a handful of faint trails. However, when you do finally discover a bright one, the frustration and disappointment will be forgotten in an instant.

Photographing the Perseids

RECOMMENDED EQUIPMENT

DSLR, fast medium to wide lens, remote shutter release

THE BIG PICTURE

A LITTLE BIT OF PLANNING CAN MAKE A WORLD OF DIFFERENCE

This year the Perseid meteor shower is set to be a good display because the Moon is essentially new during the period of peak activity. Meteor photography isn't, in theory, that demanding but there are considerations to be made to get the best results. A wise choice of lens and forethought about how

to orientate and point the camera can make a big difference to your results. Then there are the practicalities such as moisture build-up on the lens and battery and storage management, all of which will have a big impact on how successful your meteor photography turns out.

The Perseid shower is perhaps the best known of the annual meteor showers with good activity in mild weather. August nights are also short, leaving time for sleep after a full night's session. Compare this to the higher activity Geminid shower which peaks in chilly mid-December. A full night of Geminid watching takes 12 hours compared to 4.5 hours for the Perseids.

The number of meteors that an individual or camera can see is greatly affected by the altitude of the shower radiant and the clarity of the sky (the

radiant being the area of sky from which shower meteors appear to emanate – an effect of perspective). Sky clarity and brightness also have a massive impact on meteor numbers and a big nuisance here can be the Moon. However, this year new Moon occurs on 11 August, so with the Perseid peak predicted to occur on the night of 12-13 August, the conditions couldn't be better. Of course, there's still room for the weather to ruin the show.

Fixed or tracking platforms can be used. A fixed tripod will result in the stars

✉ Send your images to:
hotshots@skyatnightmagazine.com

STEP BY STEP



STEP 1

Fixed or tracking mounts can be used. Make sure the camera's view isn't compromised by foreground objects. Framing is down to personal preference but including the radiant produces some striking images. If you're having trouble deciding, then centre on the Summer Triangle in the first half of the night, and switch to look east in the second half.



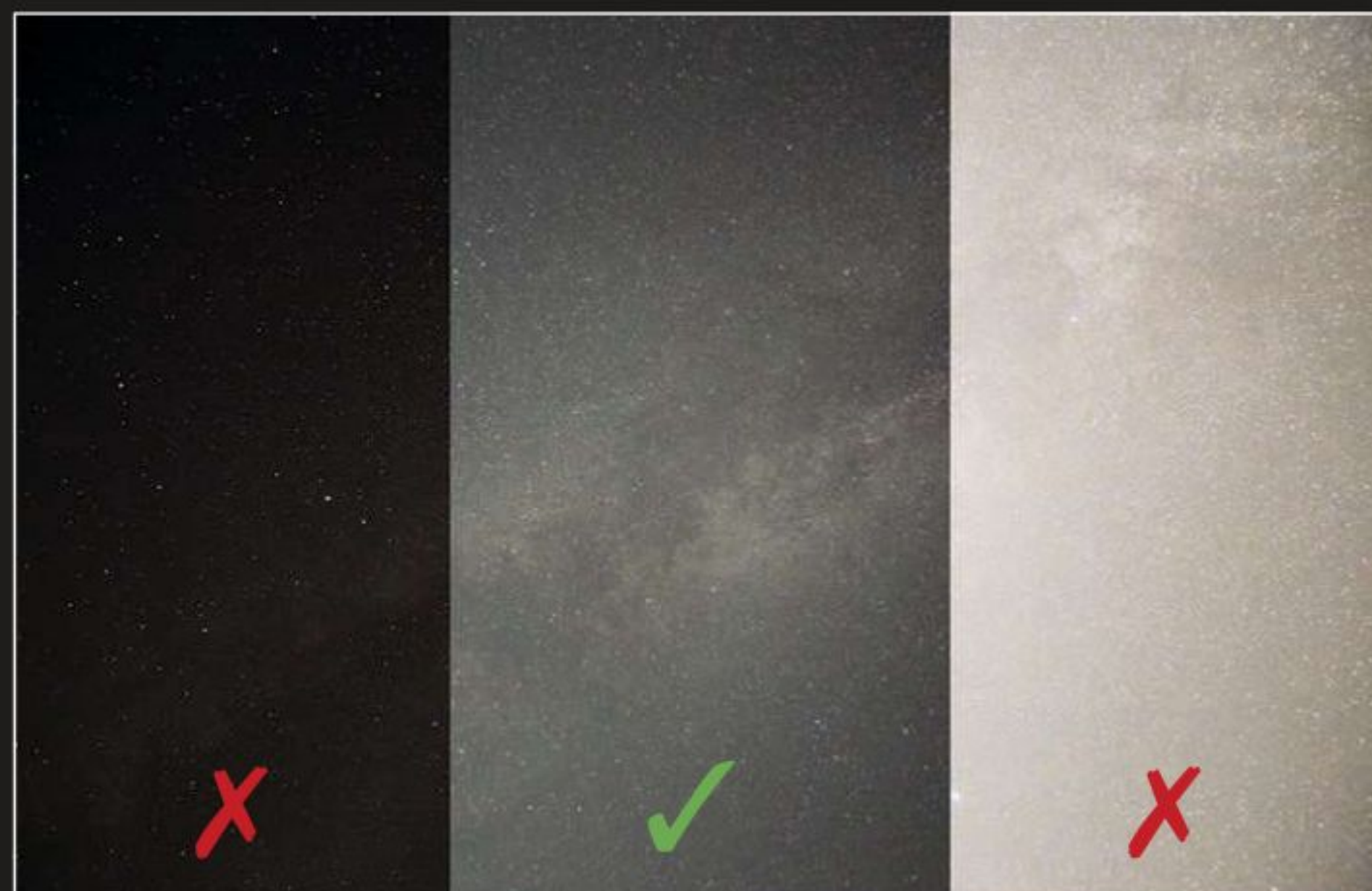
STEP 2

Choose a fast lens with a relatively wide field of view. A fisheye lens will increase the chance of trail capture but may make them appear indistinct. A focal length around 20-35mm for full frame or 12-22mm for smaller sensors works well. A 12V hairdryer or dew-heater will keep condensation at bay. Check your camera's date and time settings.



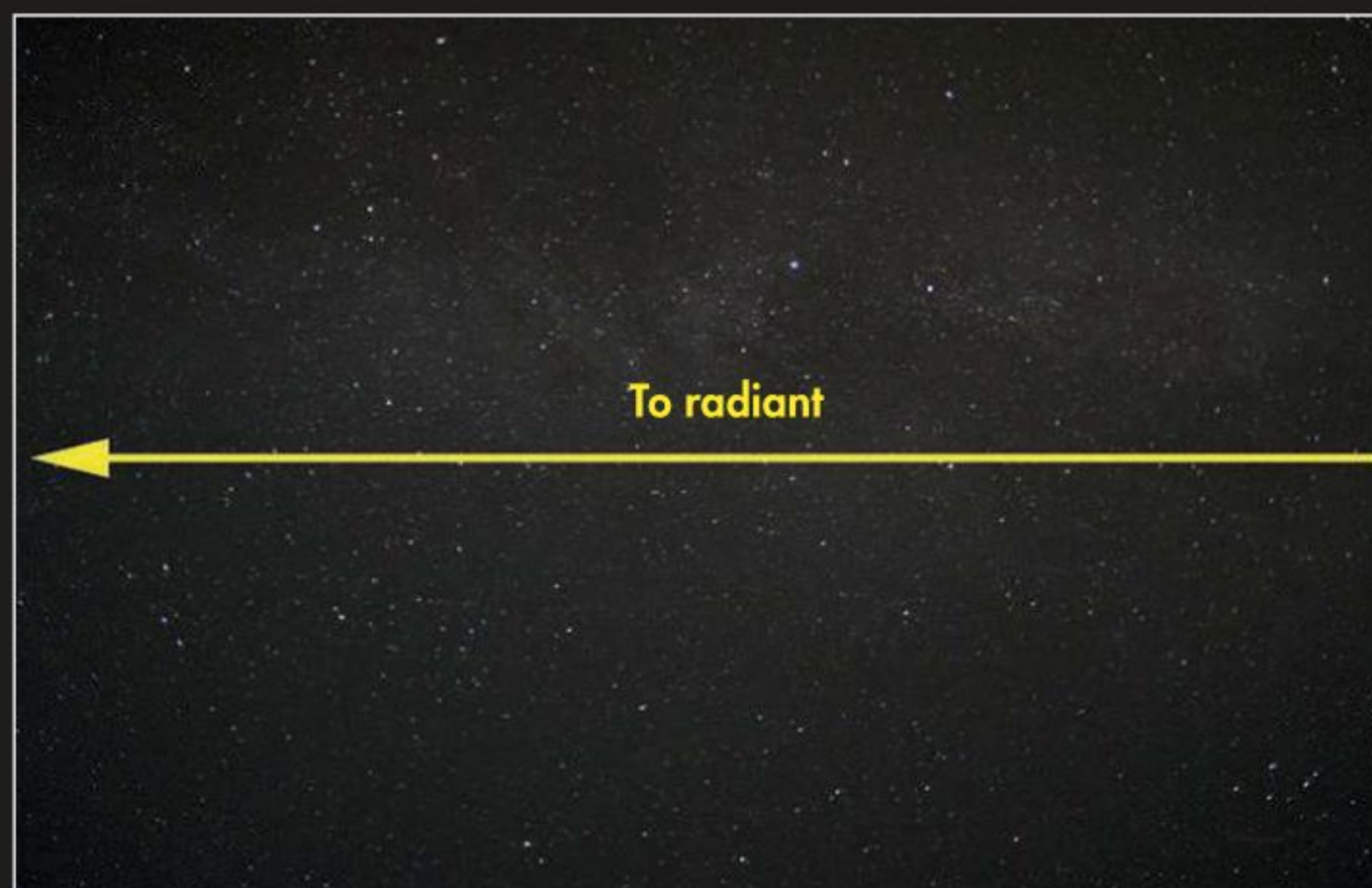
STEP 3

RAW format will give the best results but will also produce larger files, potentially clogging up your memory card. Set your lens to manual focus and pre-focus at infinity. Use the lowest f/number but consider closing by a couple of stops if stars at the edge of frame are distorted. Use an ISO setting around half to two-thirds your camera's maximum.



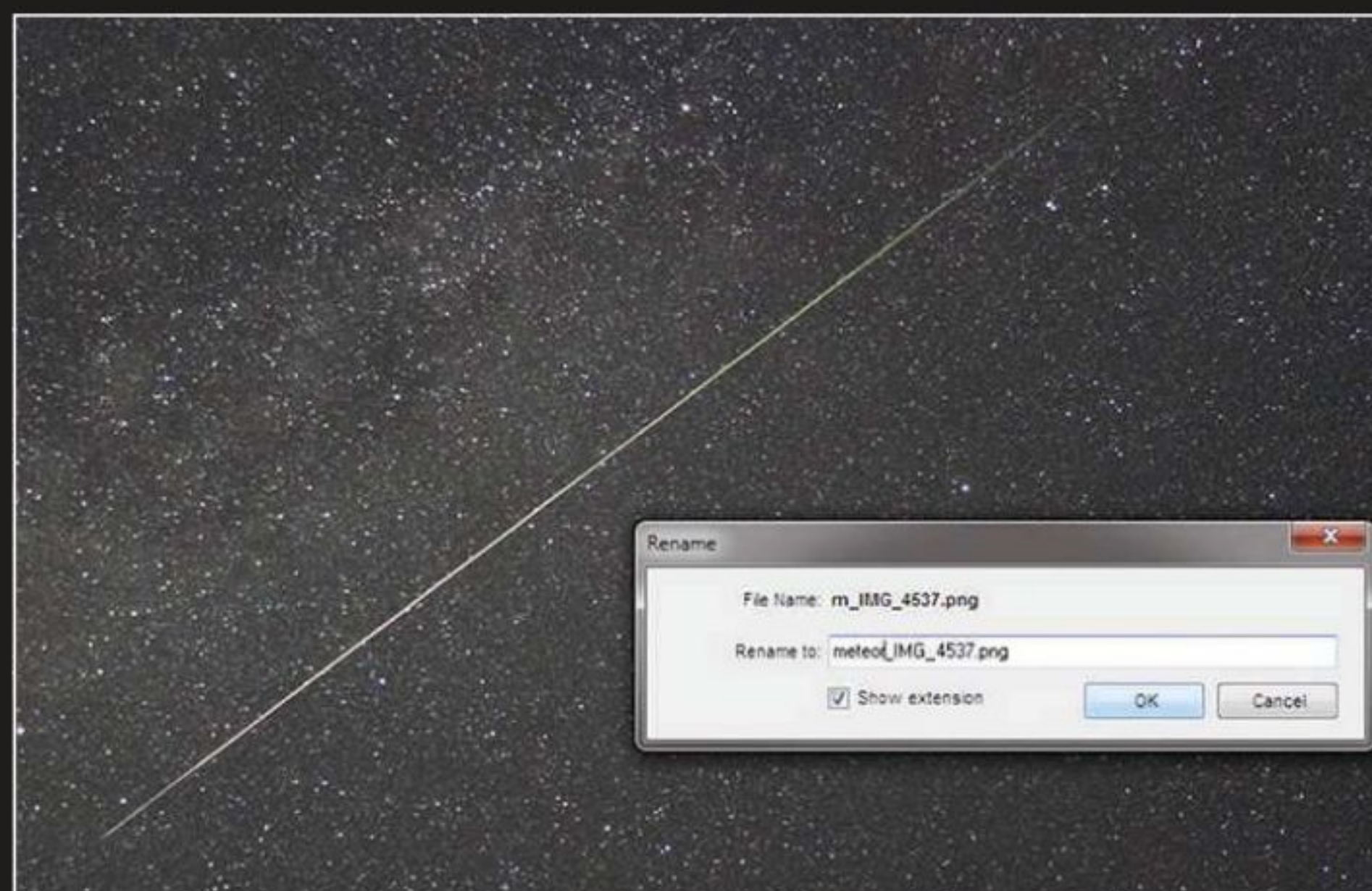
STEP 4

Set your camera's shooting mode to continuous and the exposure to 30s. Take one shot and examine it. If light pollution causes the image to look over-exposed, consider lowering the ISO. Repeat this review/alter process until you're getting the correct level of exposure as shown above. Attach a lockable remote shutter release cable to your camera.



STEP 5

Orientate the camera so that it points at an altitude approximately two-thirds up the sky. Arranging the frame so that its central long axis points to the shower radiant means that any long trails you capture have a good chance of being caught in their entirety. If using a tracking mount consider placing the radiant close to one corner of the frame.



STEP 6

When done, download the images to a computer and check each one for trails. A program such as the freeware FastStone Image Viewer (www.faststone.org) is ideal as it allows you to view full frame, paging between images via the keyboard or mouse. If you find a trail, rename the file giving it a prefix "meteor_" to make it easier to locate later.

Binoculars are an ideal and relatively inexpensive tool for taking your first steps into astronomy



Take it FROM ME

Tips from the astronomy experts

Will Gater talks to experienced astronomers to discover the secrets of stargazing and astrophotography developed over hundreds of hours of observing, imaging and processing

With the nights already starting to get longer there's no better time to brush up on your skills in preparation for the stargazing season ahead. One of the best ways to learn imaging and observing techniques is to pick the brains of knowledgeable friends who can offer you advice, or even show you how something's done. And that's why, in this issue we thought we'd speak to four experts in their fields to find out the most useful things they've learnt over the years, what mistakes to avoid and the most important things they think every beginner should know. Over the next few pages you can find the distillation of those conversations and we hope it'll be just the thing to guide you through those crucial early steps. ►



ABOUT THE WRITER

Will Gater is an astronomy writer and presenter. Follow him on Twitter at @willgater or visit willgater.com

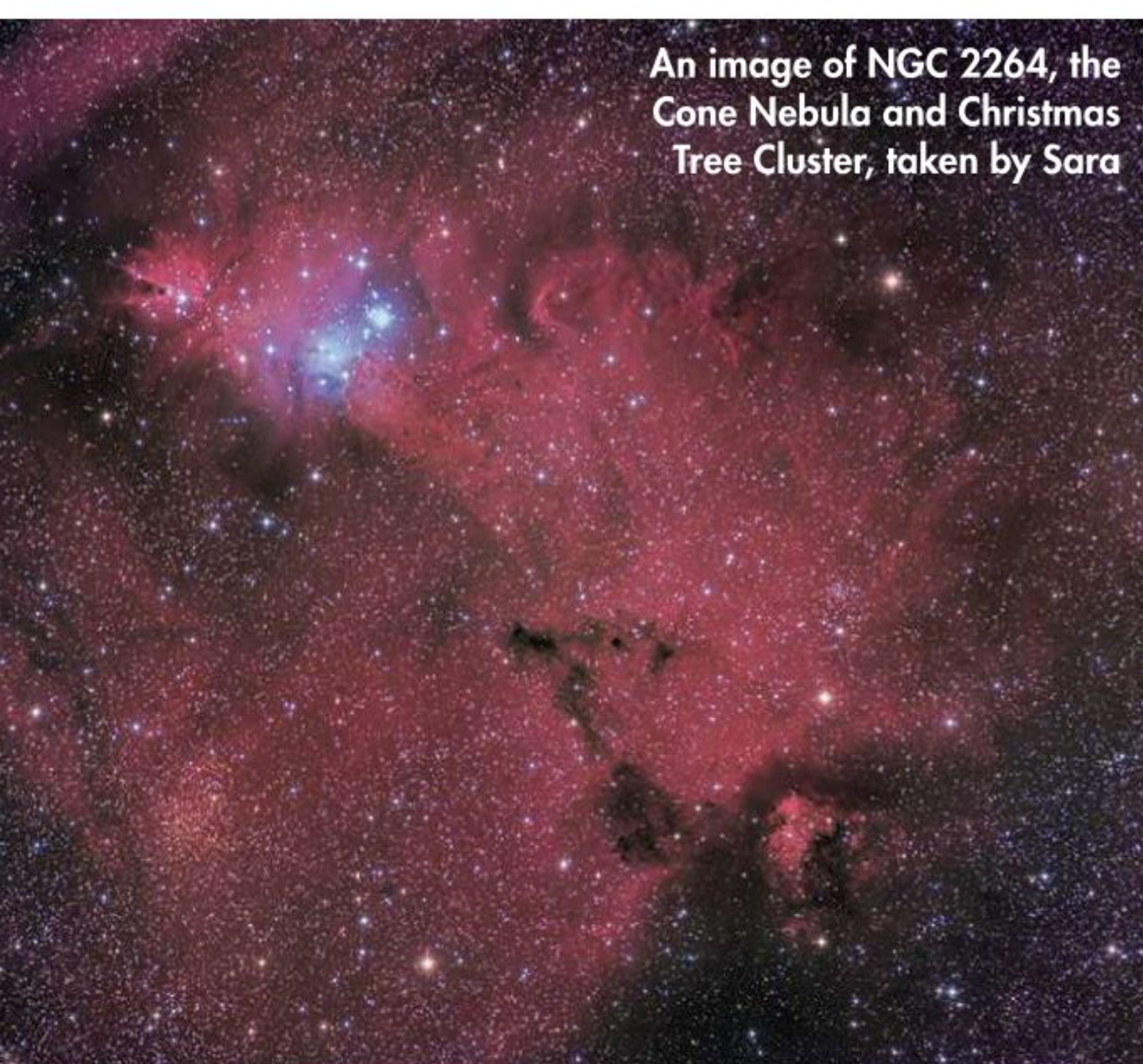
BABAK TAFRESHI/SCIENCE PHOTO LIBRARY



Sara WAGER

DEEP-SKY ASTROPHOTOGRAPHER

Sara started out in astrophotography in 2010. With the help of astronomy forums and books, she learnt imaging techniques and is now one of Europe's leading deep-sky astrophotographers. From her observatory in Spain she regularly produces stunning pictures of galaxies, nebulae and star clusters



An image of NGC 2264, the Cone Nebula and Christmas Tree Cluster, taken by Sara

"I would say the biggest challenge in deep-sky imaging is getting used to the mount, so that you're able to polar align. Without polar alignment you're not going to get longer exposures – certainly if you're not autoguiding.

"People seem to think there's a rite-of-passage in which you go from a DSLR to a one-shot colour CCD camera and then to a monochrome CCD. I don't necessarily think people should feel that they have to progress like that. If you've got the inclination and you think it's going to be a hobby that you'll enjoy then buy secondhand equipment and just jump in at the deep end.

"Your neighbour's probably not going to be doing astrophotography as well so they can't stand there and help you, but that doesn't mean you're on your own. Forums are fantastic – I've gained so much information from them and made so many friends it's unbelievable.

"I've learnt that refractors are far easier to use and, for me, are the better option. I started off with refractors before moving on to a Schmidt-Cassegrain telescope, a Ritchey-Chrétien and then an optimised Dall-Kirkham. But I've gone back

to a refractor because it's just easier. I don't want to waste time faffing around; I just want to switch everything on and go.

"As you get more experienced the way you compose a shot changes. You learn to balance things out, look around and see what else is there. I think that's really quite important because that ultimately gives you more interesting pictures.

"When it comes to executing that composition, I've found plate solving software is incredible. It'll take a picture of the sky, compare it to various catalogues that it's got on record and then tell you exactly where you are. For example, say you want to photograph the Pinwheel Galaxy, M101, and have framed it in the top left-hand corner. You can tell the software this is where you want it to go and it'll take a picture, then say, 'Actually you're 6,000 pixels away', and move the frame by 6,000 pixels. It'll take another picture, then say, 'You're still three pixels out' and make the three pixel adjustment. After a few shots you'll be in exactly the right place night after night and can even go back to it year after year. With an image from last year, I can plate solve it then ask the software to point the scope at the same spot and that's where it goes."



Top3

Sara's top tips for deep-sky imaging

COMPOSITION

"Think about what you're imaging and if there's anything else nearby that you can include that will add to the image."

FILTERS

"With narrowband filters, pick your target appropriately because some targets – galaxies, for example – aren't going to respond at all to narrowband imaging."

EASE-OF-USE

"Create a setup that's as simple as possible – something with a sturdy mount, that's quick to collimate and easy to get working properly so it won't eat up your valuable imaging time."

◀ Sara's image of M13, the Great Globular Cluster in Hercules



Richard FLEET

VISUAL OBSERVER

It was the Moon landings that steered Richard toward astronomy. One of his early optical instruments was a pair of Second World War binoculars, which he recalls using to observe the Andromeda Galaxy. Today he's an experienced visual observer, astrophotographer and an expert in meteor astronomy



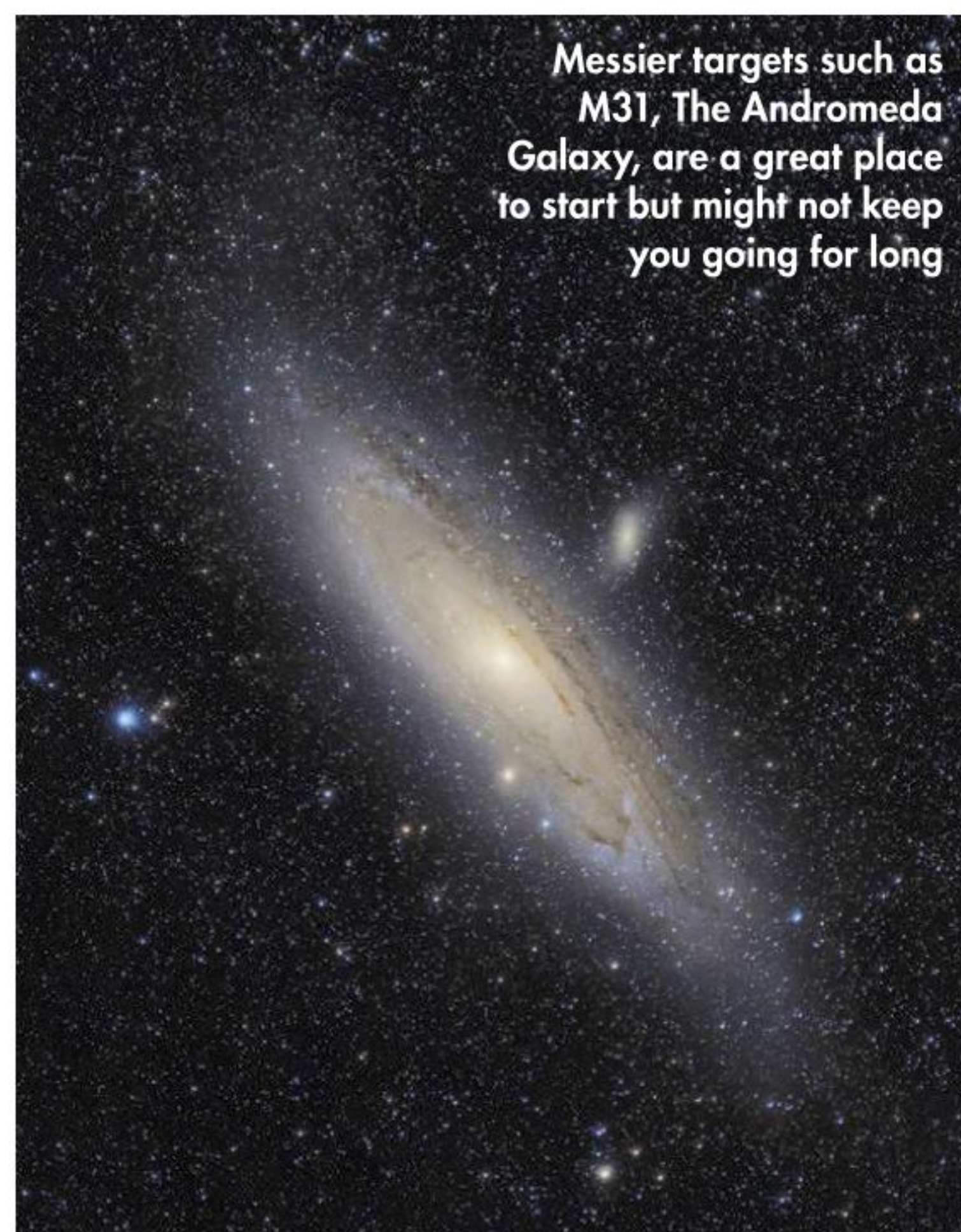
Binoculars are a great way to get a taste of astronomy before spending big money on a scope

"Beginners often ask me what telescope to buy and I reply: 'Don't buy a telescope. Just get a pair of binoculars and learn how to use them.' If what you see through the binoculars is impressive, then consider investing in a telescope. Astronomy is impressive, but it's not necessarily a visual spectacle – it's understanding what you're looking at that's the key. Binoculars are enough to do that.

"If you do decide that you want a telescope, don't buy one until you've tried viewing through the telescope you intend to buy and have experienced the sort of views you're going to see with it. Judging purely on the pictures of the views a telescope can offer often leaves people disappointed by what they actually end up seeing.

"With telescopic observing I think you need to be interested in something. If you're just looking at Messier objects you'll run out of targets quite quickly. I got interested in variable star observing because a member of my local astronomical society encouraged me to view things over a long-term. With variable stars you don't see what's going on during a single night. You have to build up a series of observations to understand what's happening. So I think you've got to do a bit more than simply spotting objects, otherwise you're not really getting the benefit. It's nice to get the Messier objects, but what do you do once you've seen them all? This is where things like variable stars and comets come in.

"One of my big regrets is that I don't write things down enough. I don't keep a diary and I think, looking back, there are a lot of things I've forgotten. The background around an observation is often just as interesting – not so much what I saw, but the adventure of observing it. Those are just memories for me now and eventually I'll lose them." ►



Messier targets such as M31, The Andromeda Galaxy, are a great place to start but might not keep you going for long

Top3

Richard's best-loved observing memories

AUGUST 2017 TOTAL SOLAR ECLIPSE

"As an emotional experience and a visual spectacle you can't beat it."

UK AURORAL DISPLAY OF 6 APRIL 2000

"That was absolutely stunning. We got out and went a few miles away to an area with darker skies between Reading and Newbury. It was fortunate that we did because at one point we were able to see orange arcs and streamers – it was like a cathedral of light."

PEAK OF THE LEONID METEOR SHOWER

"That was about the only time that you could describe it as being a shower. It was really spectacular because we had fireballs every few minutes."



Lyn SMITH

SOLAR OBSERVER

Lyn has been fascinated by astronomy since she was seven, but it was a programme on solar observing, presented by Sir Patrick Moore, that sparked her specific interest in our nearest star. Today she's the director of the British Astronomical Association's Solar Section



Lyn using her 3.5-inch Meade refractor for solar projection

"When you start observing it can feel like there's a lot of pressure on you to become an expert on everything straight away, and trying to do that isn't what you want to do at first. You need to enjoy it. You need to start simple, learn a little bit and then progress onto the next stage.

"Never look through a telescope at the Sun unless you've got a solar filter on it. You can look through a telescope as long as you have a good-quality solar filter that uses Baader AstroSolar Safety Film – that gives you a nice, white, silvery image. Alternatively you can buy a Type 2 glass solar filter and put that over the objective end, which will give you a kind of yellowy-orange Sun.

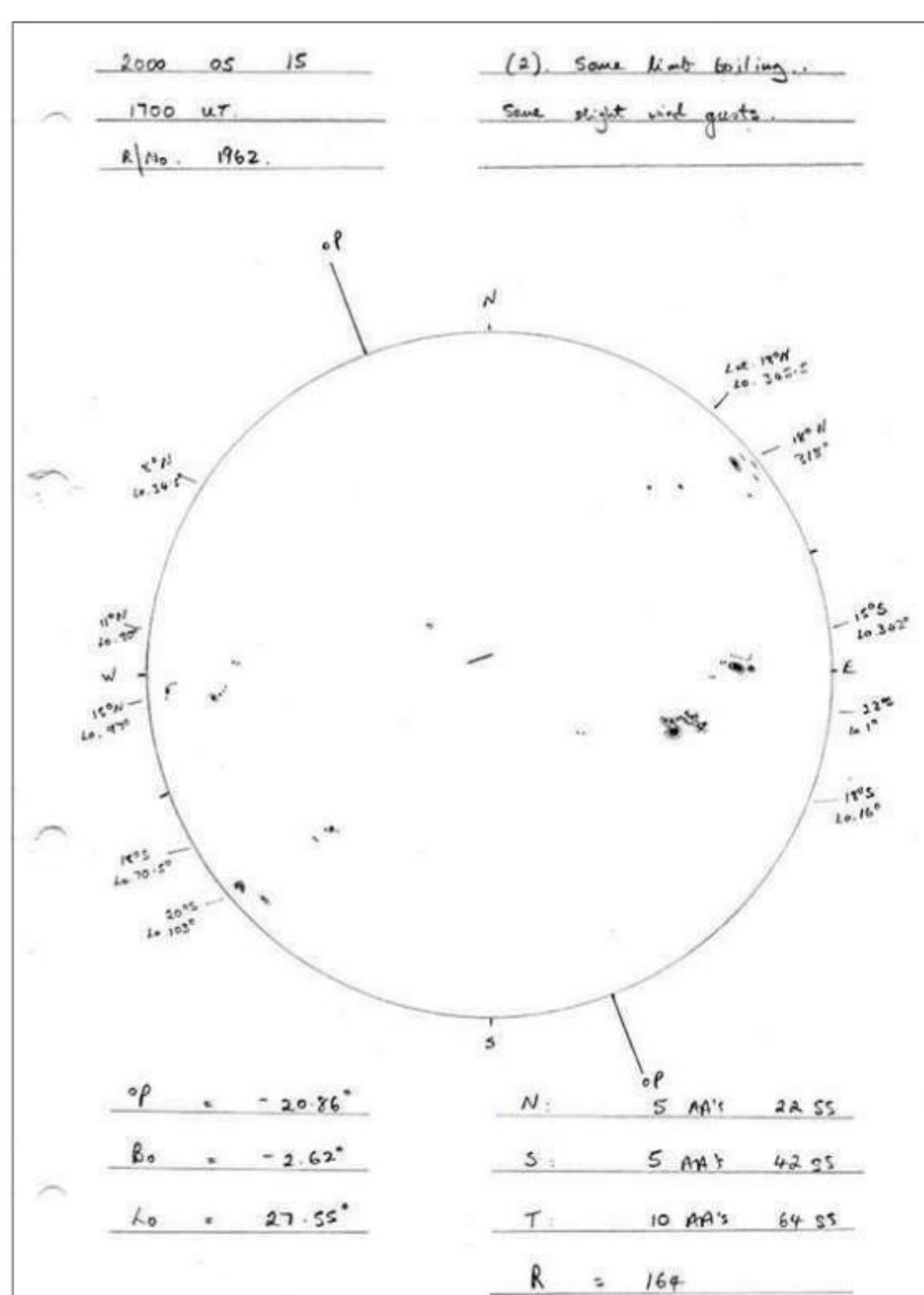
"The good news about solar astronomy is that small is beautiful. Normally in astronomy you're trying to capture as much light as possible, so you need a big aperture. With solar astronomy it's the opposite: you've got too much light so a nice small-aperture telescope is what you're after.

"I sketch every single observation, which I think really helps. If you're trying to count sunspots or anything, you need to draw it. It helps your brain sort out what's there and helps you count. It's all

too easy to just look at the full picture, but when you're drawing something you have to concentrate more on the detail.

"Bring the sunspot, filament or whatever you're looking at into the centre of the eyepiece. Then you'll see it far better. Wait for that moment of clarity, of fine seeing. There's that fraction of a second where it's so clear you see everything and then it's gone again. That's why observations take a while: you need to keep waiting for that moment of perfection and then quickly sketch it down.

"The most difficult thing for me to comprehend as a beginner was the orientation of the solar disc. It can be so simple to work out east from west when you know how, but I wish I'd had someone to tell me when I first started. Just let the solar image drift through the eyepiece and the first limb to slide out of view is the western limb. That's a really good thing to get in your head."



PROTECT YOUR EYES

Solar observing can be dangerous. Never view or photograph the Sun without using a certified solar filter that has been sourced from a reputable supplier and which is used and installed as per the manufacturer's safety instructions. Also, be sure to remove or cap any finderscopes your telescope may have prior to observing.

Top3

Lyn's favourite solar phenomena to observe

A LARGE AND COMPLEX SUNSPOT GROUP

"Cooler regions of the Sun's 'surface' that appear as dark blemishes on the bright solar disc."

AN ERUPTIVE PROMINENCE

"A vast cloud of plasma leaping off the Sun – these are only visible using specialist hydrogen-alpha solar telescopes and filter systems."

A SOLAR FLARE

"A powerful explosion on the Sun that appears as a very bright patch (typically near an active region or large sunspot). You can view these through specialist hydrogen-alpha-filtered solar telescopes."

◀ Sketching sunspots gives you both a greater insight into and a record of your observations



Pete LAWRENCE

HIGH-RESOLUTION LUNAR AND PLANETARY IMAGER

Today, Pete is an experienced imager of the Moon and planets but his first shot of the Moon was taken by pointing a digital camera down the eyepiece of a telescope. He now uses high-frame-rate cameras and a large-aperture Schmidt-Cassegrain telescope to capture spectacular pictures of our celestial neighbour



One of the mosaics
Pete's created from
many images of
the Moon

"A big danger in astronomy, as in many walks of life, is that once one method of imaging the Moon and planets becomes second nature, you tend to assume that it's the only method there is and that you shouldn't vary from it. That's wrong. You shouldn't assume that the way you're doing something is the only correct way – you should always experiment and try different things. And don't be afraid of making mistakes.

"I made plenty of mistakes when I started out. My first images of Mars looked like somebody had taken a photograph of a baked bean because it showed very little detail – it was just an orange blob. It needed that push to increase the image scale in order to bring out some of the surface details. Image scale is basically how big something looks on your

imaging chip. The longer the focal length of the telescope the larger the object you're imaging will appear. You can't change the physical focal length of your telescope but you can change the effective focal length by using an optical amplifier such as a Barlow lens or a Powermate. For example, a 2x Barlow will give you a focal length that's effectively two times your telescope's natural focal length.

"But beware: there is a danger associated with doing this. If you increase the image scale too far the planet or the Moon will just look like mush because you need perfect conditions to do that. You're not using the camera's pixels at their optimum efficiency.

"One of the best ways of processing an image – whether it's deep-sky, planetary or lunar – is to fiddle about with it to create your final image, then walk away from it for 20 minutes or more. When you come back and sit down in front of it, your image will either look good or it'll look awful. Don't worry if it looks awful, everyone produces bad images from time to time. When you're processing it's all too easy to tweak an image to death, but if it's not working, just walk away. When you come back you'll see the processed result for what it is." **S**



Top 3

Pete's top tips for lunar and planetary imaging

1. "Make sure your telescope's optics are collimated properly."
2. "Make sure the scope has cooled down to an equilibrium temperature with the outside before you begin imaging."
3. "Make sure your focus is spot on. Go through focus, out the other side and then come back in again through the focus point. Do that about half a dozen times until you know what the focus position looks like."

◀ Experience and experimentation help Pete create detailed images, like this one of Jupiter

Preparing for MARS

Analogue astronaut **Niamh Shaw** explores the Earth-based missions helping humanity prepare for our journey to Mars

**ABOUT THE WRITER**

Dr Niamh Shaw is an engineer, scientist and analogue astronaut who has participated in Mars missions in Utah, US and Negev, Israel

Mars is hot right now. SpaceX recently launched a Tesla car towards the Red Planet courtesy of its Falcon Heavy rocket; the Curiosity rover has been sending us revealing images of its arid surface for over six years; and finally setting human feet there now seems a tantalisingly close prospect.

But are we really as ready to colonise the Red Planet as some would have us believe? We might be able to deploy rovers to Mars, but humans are a whole other matter. How do we prepare astronauts

for living in isolation for sustained periods of time with limited water, food and power? As interest in manned Martian missions mounts, many countries are looking to analogue missions on Earth as way of providing answers.

Since 2001, Earth-based test facilities have been simulating conditions on Mars at desert, volcanic, polar and underwater aquatic environments in Hawaii, Chile, Canada, Spain, Florida, the Arctic and the Antarctic. Each of these analogues focuses on specific aspects of extreme environments: psychosocial and scientific studies of crews and ►



► Romain Charles (bottom row, far left) with the other members of the Mars-500 crew, which spent a year in isolation

► procedures, or prototyping specialised equipment such as rovers or spacesuit designs.

Mars-500 was a psychosocial isolation experiment conducted by Russia, ESA and China between 2007-2011, in which six male crew members were confined in a windowless habitat in Moscow for 520 days. “When that door closed, I decided that there was no world beyond this habitat; that’s how I got through it,” says Mars-500 crew member Romain Charles. “I would say three things were tough: food had a big effect on our morale; the daily repetition of the same experiments was difficult at times; and staying connected with family was paramount.”

The major scientific findings of the mission were presented at the Mars-500 symposium in 2012. It found that 100 days was sufficient time to gather data in confinement studies. Charles is proud of his achievement and rightfully so. He now works for ESA as crew support at the Astronaut Centre in Cologne.

Red ringers for Mars

Founded in 2001, the Mars Desert Research Station (MDRS) in the Utah high desert in the US is equipped with a permanent habitat, science dome and observatory. The area was selected for its close resemblance to Martian terrain, and the facility has hosted 194 crews who experience realistic EVAs (Extra Vehicular Activities) or ‘spacewalks’ in spacesuits under simulated conditions. Beyond the scientific studies at MDRS, the station is also a useful platform for human operations training.

Dr Michaela Musilova, chair of the Slovak Organisation for Space Activities, participated in



“When that door was closed I decided there was no world beyond this habitat; that’s how I got through it” Romain Charles, Mars-500

two missions at MDRS in 2014. “MDRS is one of the few places on this planet where I can get first-hand experience of more realistic collection procedures,” she says of the experience, adding, “I have a better appreciation of the limitations of astrobiological field sampling while wearing a spacesuit and within a tight EVA schedule.”

For similar reasons Dr Jonathan Clarke, astrogeologist and president of Mars Society Australia, has also made repeated trips to MDRS. “Crew selection is everything,” he says. “I’ve been


▼ Rick Blake, MDRS crew 173’s GreenHab officer, returns to mission’s base in the high desert of Utah



PENDING
AUDIO
DOCUMENT
STATS
OPTIONS

DIARY OF AN ANALOGUE ASTRONAUT

During her Mars analogue in the Utah desert, Niamh's daily reports to mission control revealed the struggle of being cut off from the outside world. Below is an extract from one of her reports



MISSION REPORT BY CREW 173 JOURNALIST

SOL 6

Our lives back on Earth seem a lifetime away now. Roy went looking for something in his living quarters last night and came across some US currency and brought it out to show us.

Money.

It's so strange now, when you look at money on Mars. Only seven days ago back on Earth, we couldn't do anything without it. Breakfast – \$10. Batteries – \$4. Coffee – \$3. Now we can do nothing with it. Except, perhaps, use it to rub the

mud off our boots as we re-enter the airlock post Extra Vehicular Activities.

That's the interesting thing about being here on Mars. When you strip your daily routine back to simply surviving the elements and completing daily tasks, life gets a whole lot easier. You can't help but reflect on life back on Earth. And all the stuff. The hoards of books that I probably haven't opened in years; the wardrobe of clothes, shoes and odds and sods; bed linen, carpets, cushions, bicycles, cafes, buses, trains. All useless here.

High value products on Mars: thermals, boots, camera, internet, heat, the solar generator, water, a functioning toilet, food, chocolate and coffee. Lots of coffee. Tinfoil to cover our plates at mealtimes and cut down on washing up. Movie night, sunrise, sunsets, laughter, sharing stories, the crew: these are our currency now.

Crew 173 outside the MDRS habitat. Niamh Shaw (bottom row, left) flies the flag for Ireland



Niamh Shaw on an EVA with the MDRS habitat, on the San Rafael Swell, Utah, in the background



on many SIMs over the years, some lasting up to three months and each one is different.”

I couldn't agree more. I participated in an MDRS mission in early 2017 as crew journalist and artist for Crew 173, experiencing first-hand the claustrophobia of living in a confined space. The impact of every interaction with your crew is magnified, whether positive or negative. Thankfully I was blessed with a super crew.

Creating new fields of research

A key objective of The Mars Society founder Robert Zubrin in establishing MDRS and its polar-based sister facility Flashline Mars Arctic Research Station (FMARS) was to create a legacy. “My goal has always been to eventually be made obsolete; that MRDS would provide a platform to open up a new field of research, new players too,” he says. There appear ►



An analogue astronaut on an EVA for the AMADEE-18 mission in the Dohfar region of Oman



AMADEE-18 analogue astronauts test out their robotic rover



AMADEE-18 analogue astronauts Kartik Kumar and Stefan Dobrovlny

► to be indications of this very legacy emerging: the Austrian Space Forum (OeWF) established by former MDRS Crew 11 member Dr Gernot Groemer, is a key player in the steady growth of this citizen science organisation for space professionals. “Our missions are less about a personal experience of a confined simulated mission for the analogue astronaut,” he says. “We focus instead on using the analogue location to test equipment and run experiments under those conditions.”

Their latest mission, AMADEE-18, is part of a 10-year strategy focussing on procedures, workflows, spacesuit design and operational environments to provide a perfect requirement document for the first Mars mission. Dr Carmen Koehler, OeWF analogue astronaut since 2015, participated in the AMADEE-18 mission in the Dhofar region of Oman in February 2018. “15 of us were in isolation, and of those six were analogue astronauts, actually going outside the habitat,” she explains. “We had very long working hours, the workload was very high, but I loved it.” The research findings of all OeWF’s analogue missions are available on its website (oe wf.org).

Israeli geologist Roy Naor is an alumnus of MDRS Crew 173. In 2016 he and astrobiologist Dr Reut Sorek-Abramovich and physicist Dr Hillel Rubinstein

created the Young Astronaut Academy Programme. “A key strategy of this programme was to provide an analogue facility for young students to learn science and technology subjects experientially,” says Naor. “When I returned from MDRS, we realised we could create our own analogue facility. We located a site in the Ramon crater [in Israel’s Negrev desert] and work began on designing the habitat.”

Astronaut academy

And thus, D-MARS was born; a project conceived and imagined by an enthusiastic team of 100 young Israeli space professionals. “Everyone wanted to help us,” Abramovich says. “Companies provided state-of-the-art technologies in food delivery, power systems and other facilities for the habitat. We

“D-MARS was born; a project conceived and imagined by an enthusiastic team of 100 young Israeli space professionals”

ANALOGUE DIRECTORY

At-a-glance guide to analogue missions around the world

Facility	Established	Location:	No. of crews	Crew
¹ NEEMO NASA Extreme Environment Mission Operations	2001	Florida	22	4
² FMARS Flashline Mars Arctic Research Station	2001	Arctic	14	6-9
² MDRS Mars Desert Research Station	2001	Utah	194	6
Concordia Station	2005	Antartica	14	10-15
³ Mars-500	2007	Moscow	3	6
³ AMASE Arctic Mars Analog Svalbard Expedition	2007	Svalbard	5	Up to 30
³ ESA CAVES Cooperative Adventure for Valuing and Exercising human behaviour and performance Skills	2011	Sardinia	5	5-6
HI-SEAS Hawai'i Space Exploration Analog and Simulation	2013	Hawaii	6	6
NASA HERA Human Exploration Research Analog	2014	Houston	4	4
AMADEE-18	2018	Oman	1	15
DMARS Desert Mars Analog Ramon Station	2018	Israel	2	6

¹ Underwater environment ² Run by The Mars Society ³ No longer active

▼ NEEMO is an underwater NASA analogue based in a facility called Aquarius in Key Largo, Florida

completed our first mission in February 2018 and have already completed an additional two short missions for the Young Astronaut Academy. These young students will be better equipped to work in the space industry as a consequence.” They have a full schedule of short missions planned for 2019 and will partner with an OeWF AMADEE mission in 2020.

The annual ‘Humans to Mars’ report launched at the Explore Mars summit in Washington DC in May this year provided a snapshot of current progress of



D-Mars is an Israeli initiative aimed at nurturing young prospective astronauts



all global space activities. The report summarised key findings from the major space players and agencies, their progress and challenges, including contributions made by analogue missions to the bigger Martian agenda. There are many other space agency-led analogue missions happening across the globe: Concordia at the Antarctic; NEEMO (NASA Extreme Environment Mission Operations) in Key Largo, Florida; NASA HERA (Human Exploration Research Analog) in the Johnson Space Center in Houston and HI-SEAS (Hawai'i Space Exploration Analog and Simulation) in Hawaii, to name a few. Along with contributions from other analogues all over the world they are helping us find solutions to the future survival of astronauts travelling to the Red Planet. A small contribution to the bigger issue at hand, but a contribution nonetheless. We still have much to do, but rest assured, analogues are a key piece of the interplanetary puzzle. **S**

BBC iPlayer

Watch an episode of *The Sky at Night* from 1969 in which Patrick Moore looks at images of Mars taken by the Mariner 6 probe (UK viewers only). bbc.in/2ywBnWk

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SKILLS

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Brush up on your astronomy prowess with our team of experts

The Guide



With
Stephen Tonkin

Getting started with binocular astronomy

Telescopes are great for close-ups, but binoculars give you the bigger picture



▲ **Binoculars – when you don't want to miss the galaxies for the stars**

How would you like a versatile, ultra-portable observing instrument that you can easily set up in less than a minute, which can show you hundreds of

astronomical objects you can't see with your naked eye but costs less than a single mid-range astronomical eyepiece?

Welcome to the 'humble' binoculars!

Binoculars' wide field of view makes them ideal for scanning the sky, and they are the instrument of choice for observing asterisms and open clusters too big to fit into the smaller field of view of a telescope.

While telescopes are better for seeing detail on larger Solar System objects and splitting close double stars, there are hundreds of satisfying deep-sky objects that you can see with small binoculars.

What the numbers mean

Binoculars are described by two numbers that refer to their magnification and objective lens diameter in millimetres. So a 10x50 pair has a magnification of 10x and an objective lens diameter of 50mm. You may think that higher magnifications would be better for astronomy, but they magnify hand-shake as well as the image.

For sustained handheld observing, 10x is a sensible maximum, and a 10x50 pair is a good all-rounder. Don't be tempted by zoom binoculars: good ones don't exist.

The aperture determines the amount of light captured by the objective lenses. If your eye pupil opens to 5mm, a 50mm objective lens will let in 100 times more light. Some of this will be 'lost' in its passage through the binoculars, but most of it will get to your eye; good quality binoculars generally transmit more light.

When you hold a pair of binoculars up to the light and look at the eye lenses, you'll see small circles of light, the 'exit pupils'. Ideally, they should be slightly smaller than your eyes' dark-adapted pupils. You can calculate the exit pupil diameter by dividing the objective diameter by the magnification. So a 7x42 has an exit pupil of $42/7 = 6\text{mm}$. (If you're wondering how you measure your own pupils then visit <https://bit.ly/2JPrTuo>.) You should also know the distance between your eyes' pupils, the 'interpupillary distance' (IPD), and make sure any binoculars you intend to buy or use will actually open out or close up to that width.

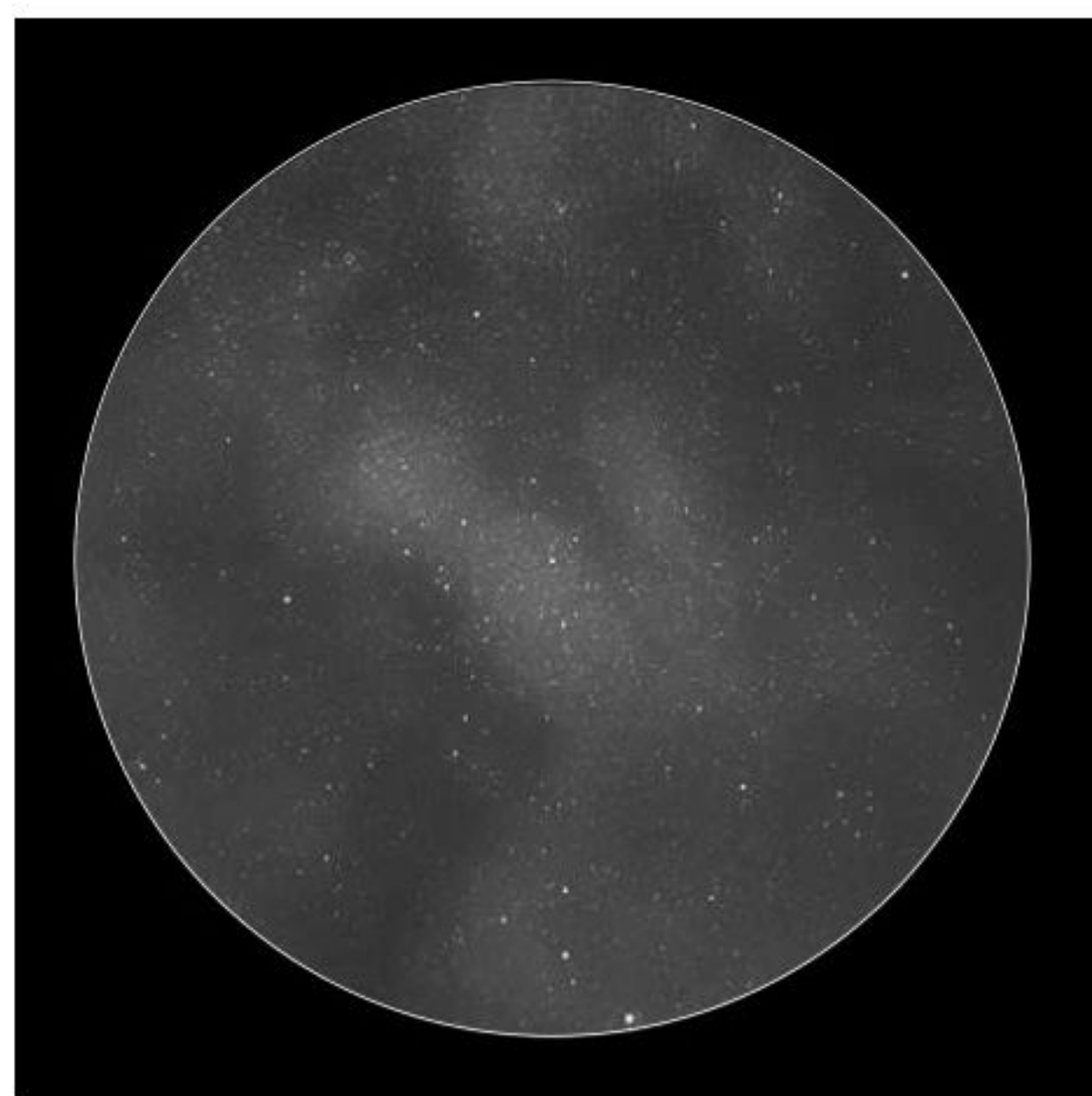
Although binoculars can usually compensate for any focal defects in your vision, if you need to wear spectacles you also need to ensure that the binoculars have enough 'eye relief'. This is the distance between the eye lens and the exit pupil; 18mm should be enough to enable you to see the entire field of view.

Stay focused

To set up your binoculars, look at a distant target and adjust the binocular hinge until you see a single circle (not the double circle you see for binocular point-of-view shots in films!). Then cap the right objective lens

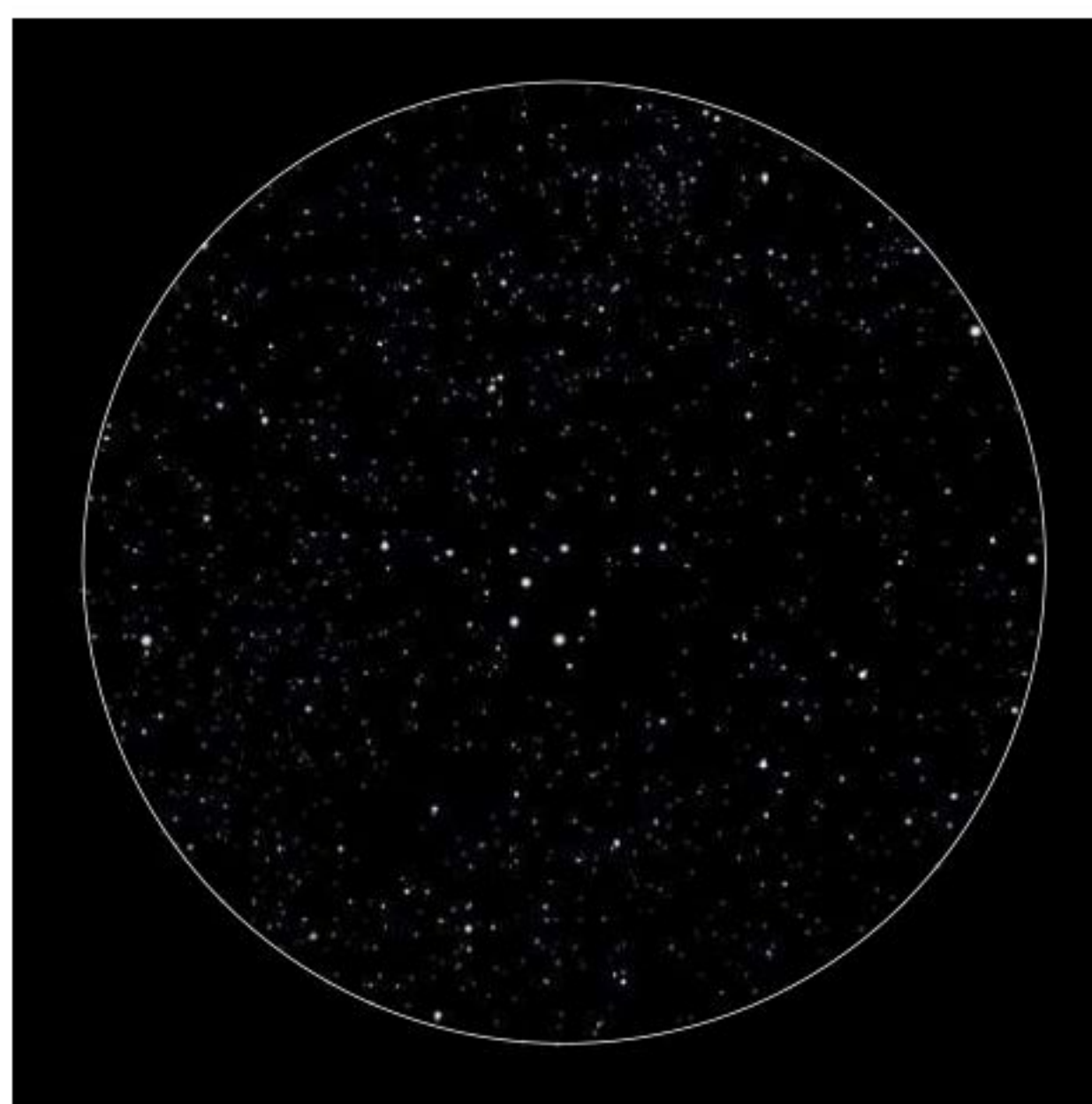
Six great objects for binocular novices

And simulated views showing what they'll look like through 10x50 binoculars



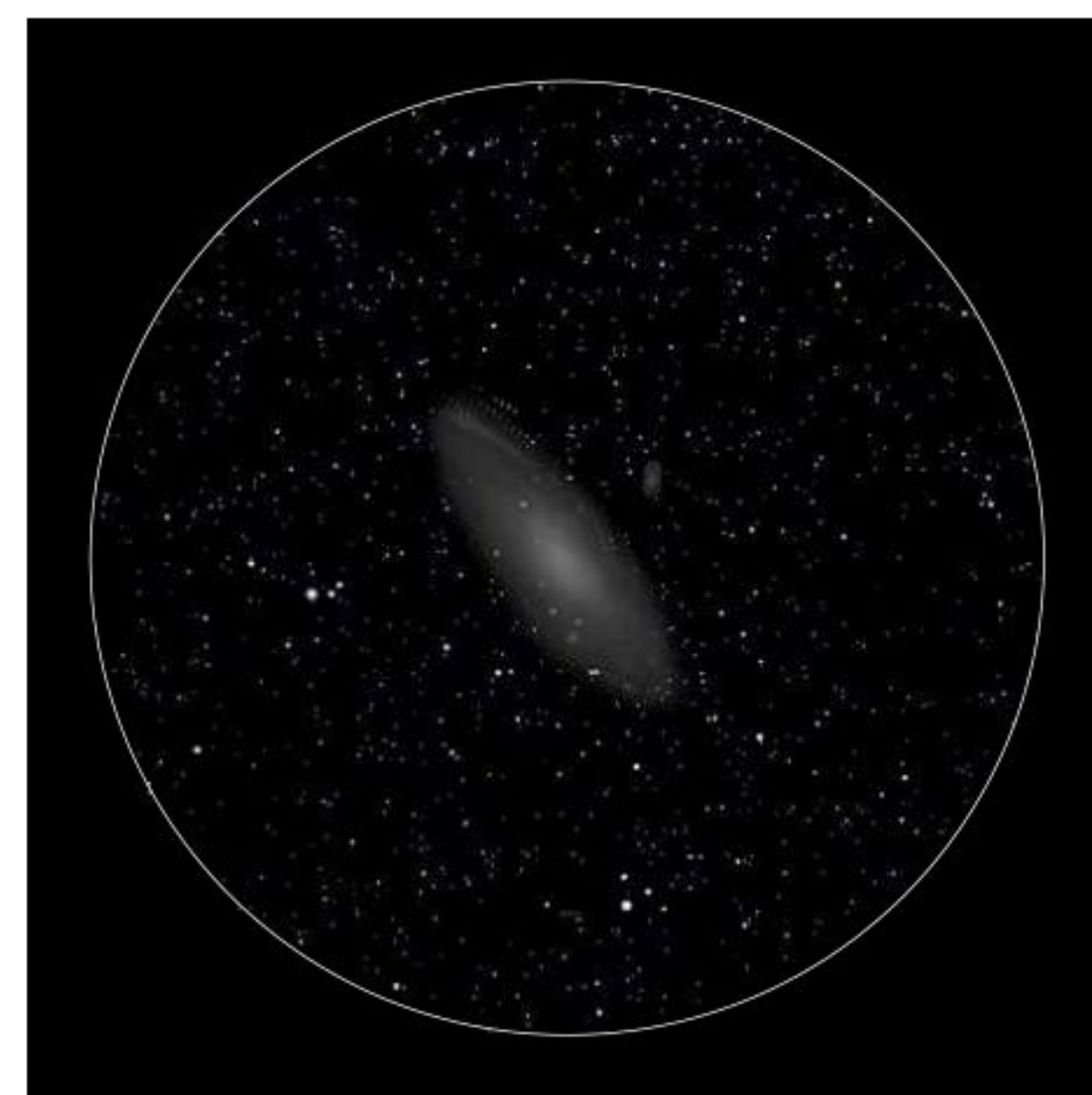
▲ M24, THE SAGITTARIUS STAR CLOUD (SUMMER)

This is the densest accumulation of stars visible in binoculars anywhere in the sky. You won't be able to count them, but you can appreciate the knots, curves and varied colours of the stars in this gap in the dust that obscures so much of the Milky Way.



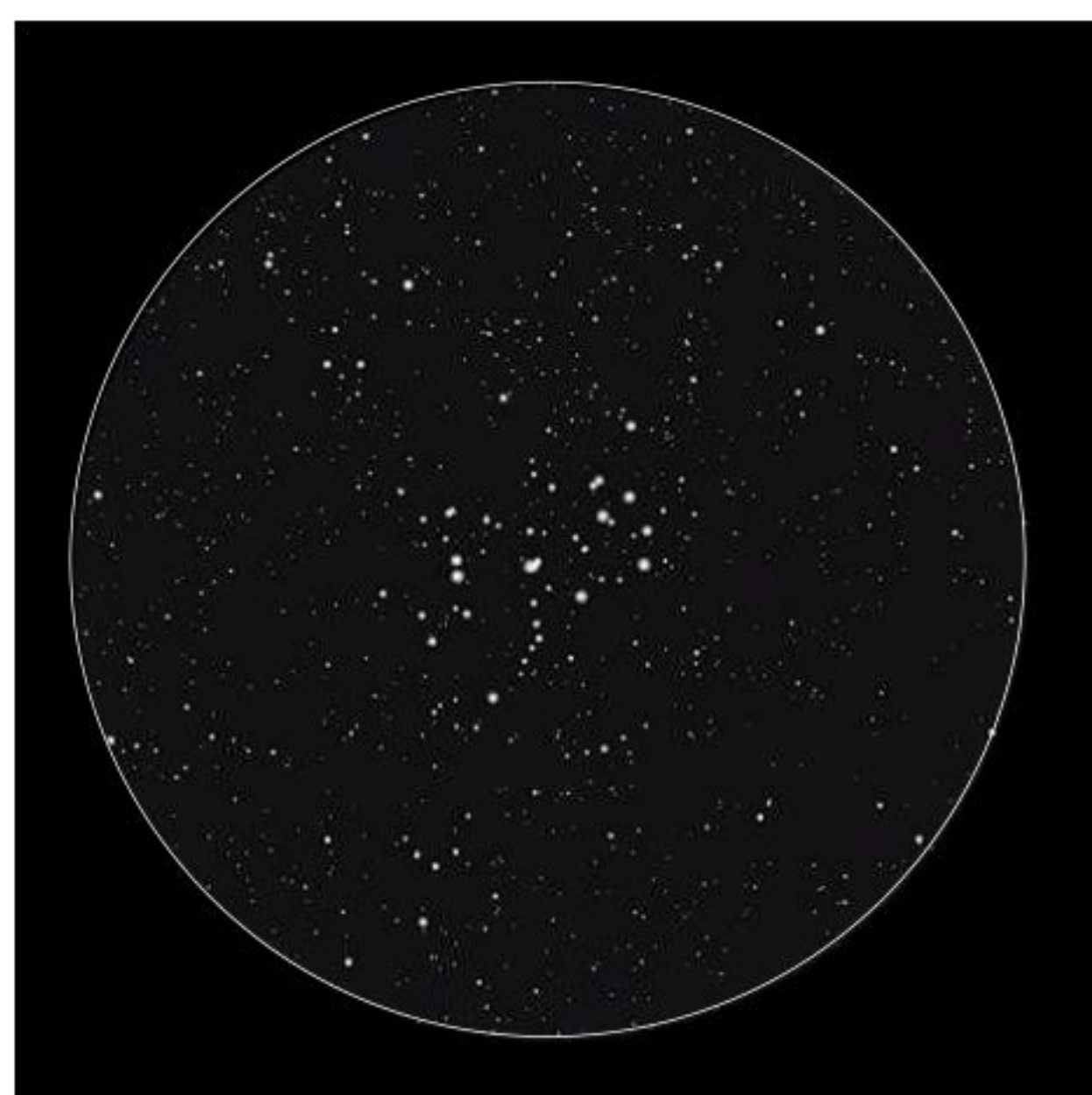
▲ COLLINDER 399, THE COATHANGER (SUMMER/AUTUMN)

Yes, there's a coathanger in the sky. It's a fun alignment of stars that will always bring a smile to your face. To locate it find easy-to-spot stars Albireo and Altair, draw a mental line between them and the Coathanger is about a third of the way along just off to the Hercules side.



▲ M31, THE ANDROMEDA GALAXY (AUTUMN/WINTER)

Although the Andromeda Galaxy initially seems to be simply an oval cloud with a brighter core, as you study it, you become aware that the light drops off slightly more abruptly on the north western edge. Congratulations – you have just detected the dust lane on its nearer side!



▲ M45, THE PLEIADES (LATE AUTUMN TO LATE SPRING)

This one's easy to locate as it forms the end of Taurus's tail, and even with the naked eye it's a splendid sight. But binoculars reveal the real beauty: bright sparkling diamonds scattered over black velvet! Wait until it's high in the sky to see it at its best.



▲ COLLINDER 70, ORION'S BELT REGION (WINTER/SPRING)

Among the hundred or so stars that you can see, note the wonderful S-shaped curve of stars that winds its way between the two right-hand belt stars. When you've had your fill, drop down to the Orion Nebula; this birth-place of stars is another fine sight.



▲ MELOTTE 20, THE ALPHA PERSEI MOVING CLUSTER (ALL YEAR)

You should see more than 50 blue-white stars in this relatively young cluster that's around 600 lightyears away. It's circumpolar, so you can see it on any clear night. Its brightest star, Alpha Persei (or Mirfak) is also the brightest star in the constellation of Perseus.

and focus the left-hand tube with the centre focus. Next, cap the left objective lens and focus the right-hand tube with the dioptre adjustment – that's the dial directly behind one of the eyepieces (usually the right-hand one) that lets the binoculars compensate for sight differences between

your own eyes. You're ready to go; from now on only focus using the centre-focus.

Turn to page 58 and pick an object from the Binocular Tour. Look at the appropriate place in the sky then, without moving your head, raise the binoculars to your eyes. With a bit of practice, you'll get the correct

region of sky every time and, by following the tours every month, you will soon have a sound 'sky knowledge' that will stand you in good stead for any future observing. **S**

STEPHEN TONKIN is the author of *Binocular Astronomy* and *AstroFAQs*



With
Mark Parrish

How to...

Make a double star eyepiece

A home-built accessory for measuring the separation of double stars



The completed double star separation calculating eyepiece – just add scope

Visual observations of double stars are an enjoyable challenge. This month's project is a double star eyepiece for making your own measurements of separation and position. With practice, you should be able to record a series of values with it, which could prove to be of scientific interest.

Our design utilises an illuminated reticule eyepiece. These are sometimes bundled with telescopes but they can also be purchased relatively cheaply online. They have a thin glass reticule inside with

an etched crosshair pattern. You adjust the lens so that it focuses on this reticule and, when you look through, the sky appears to have the crosshairs superimposed onto it.

In our design a thin wire pointer also appears within the reticule 'window' and this can be moved across the field of view by turning a graduated wooden dial. It is vital that this pointer is very thin, although you may still need to measure to its edge rather than its centre for accuracy. You can use the LED light supplied with the reticule although the wire pointer will probably remain in silhouette against the background sky

TOOLS AND MATERIALS



Tools

Coping saw; drill and bits (approx 28.5mm and 32mm for eyepiece parts, plus 3mm and 4mm for other holes and 6mm for nut inserts); small piers

Materials

Small piece of good quality 6mm plywood approx A5 size and similar-sized piece of 3mm plywood (or substitute with acrylic)

Sundries

Nine M3x25 screws and one M3x50 screw with suitable nuts (including one nyloc nut) and washers; an M5 or M6 washer for the drive screw; a small tension spring or elastic band; short length of very thin wire (an offcut from a guitar top E string, for example); small wooden or plastic bead (approx. 8-10mm); a surplus, inexpensive, illuminated reticule eyepiece; thin metal strips to make pointers

Finish

Some spray paints or wood varnish to provide a nice finish

rather than being illuminated. To take measurements a protractor is attached to the focuser tube. This should be easy enough to turn when setting up but stay in place when adjusting the unit.

To calibrate the protractor, choose a star close to the celestial equator and the meridian. Position this on the horizontal


crosshair in your double star eyepiece. With the telescope's drive switched off rotate the unit in the eyepiece holder until the star drifts perfectly along the line. Once you're happy, carefully rotate the protractor until the 90° mark is aligned with a pointer on the top of the double star eyepiece casing. Check and repeat as necessary. The eyepiece is now calibrated with the north point at zero and east at 90°.

No separation anxiety

To measure the separation and relative position of a pair of stars you are observing turn the double star eyepiece in the focuser so that they both lie on the horizontal cross hair with the primary (brightest) star at the centre. Make sure the pointer is initially set at the centre of the crosshairs. With the motor drive running, adjust the pointer to line up with the secondary star, making sure that the primary star is still at the centre. By counting the number of turns and part turns of the dial and using a simple calculation (use our spreadsheet in the download section), you can find the angular separation of the pair. Repeat and average the results to improve accuracy.

To measure the position of the secondary star relative to the primary make sure they are still both on the line and simply read off the new measurement from the protractor. It's worth rotating the double star eyepiece through approximately 180° and carefully adjusting until both stars are back on the line and re-reading the indicated angle (and subtracting 180!). Again, you can repeat this and average the findings for more accuracy.

Record your results along with the date and time. Compare your measurements with known data – making small adjustments to your calculations and thereby calibrating future observations (some well-known examples are listed on the second page of the spreadsheet).

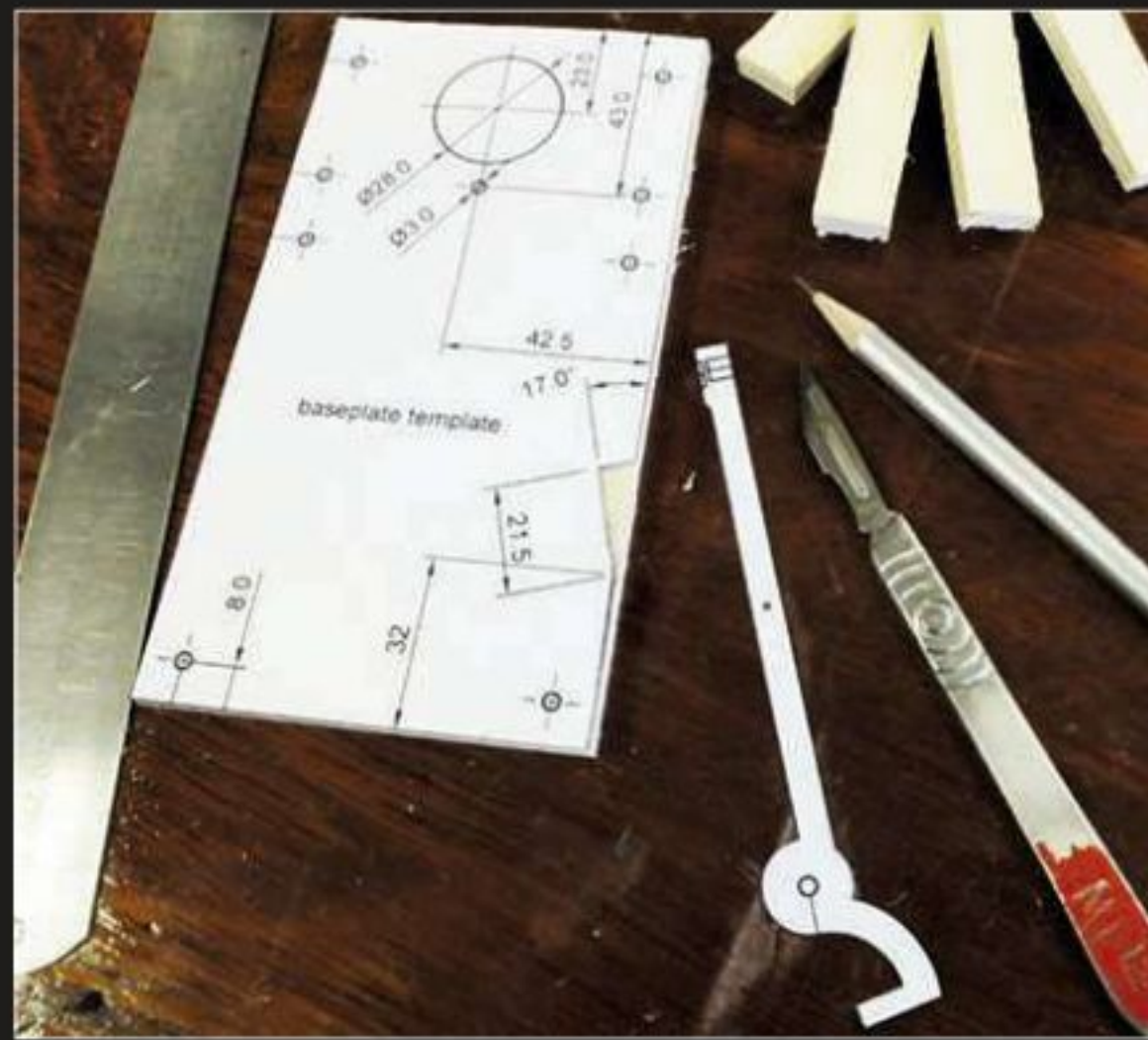
Why not turn your double star eyepiece onto other targets? You could try to measure the angular diameter of a planet or a star cluster. If you like to tinker, customise your mechanism to make it even smoother, or design customised dials that do away with the need for calculations. 

MARK PARRISH is a bespoke designer. See more of his work at buttondesignco.uk

YOUR BONUS CONTENT

For plans, diagrams and more photos visit our download site (see page 7).

STEP BY STEP



STEP 1

Print out our downloadable templates and use them to carefully mark out the plywood sections. Cut out each paper section and draw round it. It is a good idea to use a sharp point to mark through the centre of each hole to aid accurate drilling.



STEP 2

Carefully drill the holes in the case parts and the lever. It is easier to drill the lever holes before cutting it out. A pillar drill ensures a vertical hole but with care this can be done by hand. Carefully saw round the parts and smooth with sandpaper.



STEP 3

Apply some wood glue and clamp together the two blocks for the lever screw. Clamp the wall sections to the main case panel. If you don't have clamps you can use large clothes pegs or masking tape to hold the pieces in place.



STEP 4

After drilling right through the block with a 6mm drill, temporarily thread the nuts onto a screw to match the width of the block. Push them into the hole after applying some epoxy resin or superglue then remove the screw. Avoid getting glue in the threads.



STEP 5

After carefully sanding and painting the parts, you're ready for assembly. Our bead was too large, so we held it on a screw, mounted it in a drill chuck and used a file to reduce the diameter. Some experimentation may be necessary to ensure free movement.



STEP 6

Fit a rubber band or spring to keep the lever under a constant small load. Bend your thin wire to form a pointer and glue it so that it just touches the reticule. Use the printable scales to complete your dial and protractor. Finish assembly using our online instructions.

Image PROCESSING



With
Sara Wager

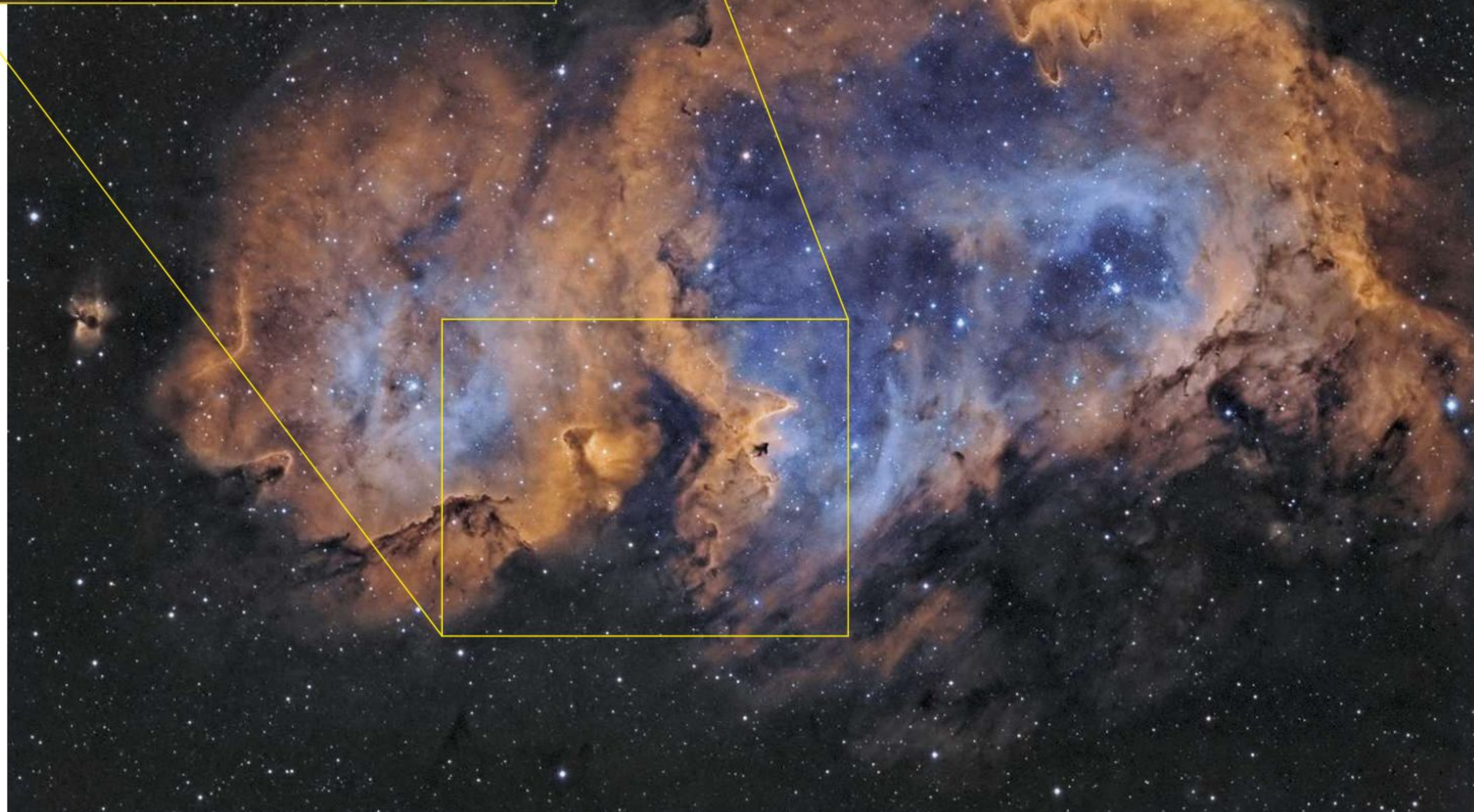
Building a mosaic using Astro Pixel Processor

When it comes to creating astral jigsaws APP helps make the process so much easier

▼ The main picture is a full-frame image of IC 1848, the Soul Nebula, and the insert shows how a different focal length and camera sensor can lead to a much smaller field of view, but with more detail

This month we look at why mosaics are sometimes necessary and how to create them seamlessly in Astro Pixel Processor (APP). Ideally there would never be a need for a mosaic, but there are many compromises in deep-sky imaging and also some very large nebulae! Some deep-sky objects are just too darned big. To fit them in their

entirety into your field of view you have to sacrifice quality and detail. So, if you want to capture the entire object but maintain the detail, there's no alternative other than to create a mosaic. Below, for example, you can see IC 1848, the Soul Nebula, filling the frame, but the insert shows part of the nebula that has been taken with a longer focal length telescope. Clearly, if you wanted to capture the complete nebula in one frame using the longer focal length



ALL PICTURES: SARA WAGER



▲ The three images that need to be stitched together to reveal the complete picture. The software requires some overlap at the edges to do its work

“If you want to capture the entire object but maintain the detail, there’s no alternative to a mosaic”

telescope then you’re going to have to piece together a rather large mosaic.

Build in some overlap

When planning a mosaic you have to factor in a degree of overlap between each frame. This ensures that the same stars appear in the edges of some frames, enabling the software to match them up and work out how the frames need to fit together. We’ve found that the best overlap is between 10-15 per cent. This can usually be set in your capture software.

If you’ve been following the previous APP articles in this series, you will by now

have a calibrated and integrated stack of data ready to use for this stage. In our example we have three individual stacks of data. We will deal with only one filter at this stage; combining individual filters to create a colour image is another process. We would strongly recommend that you stitch your mosaic together before any processing is done on the images. Even though the image may appear almost black, APP will be able to merge the data without issue.

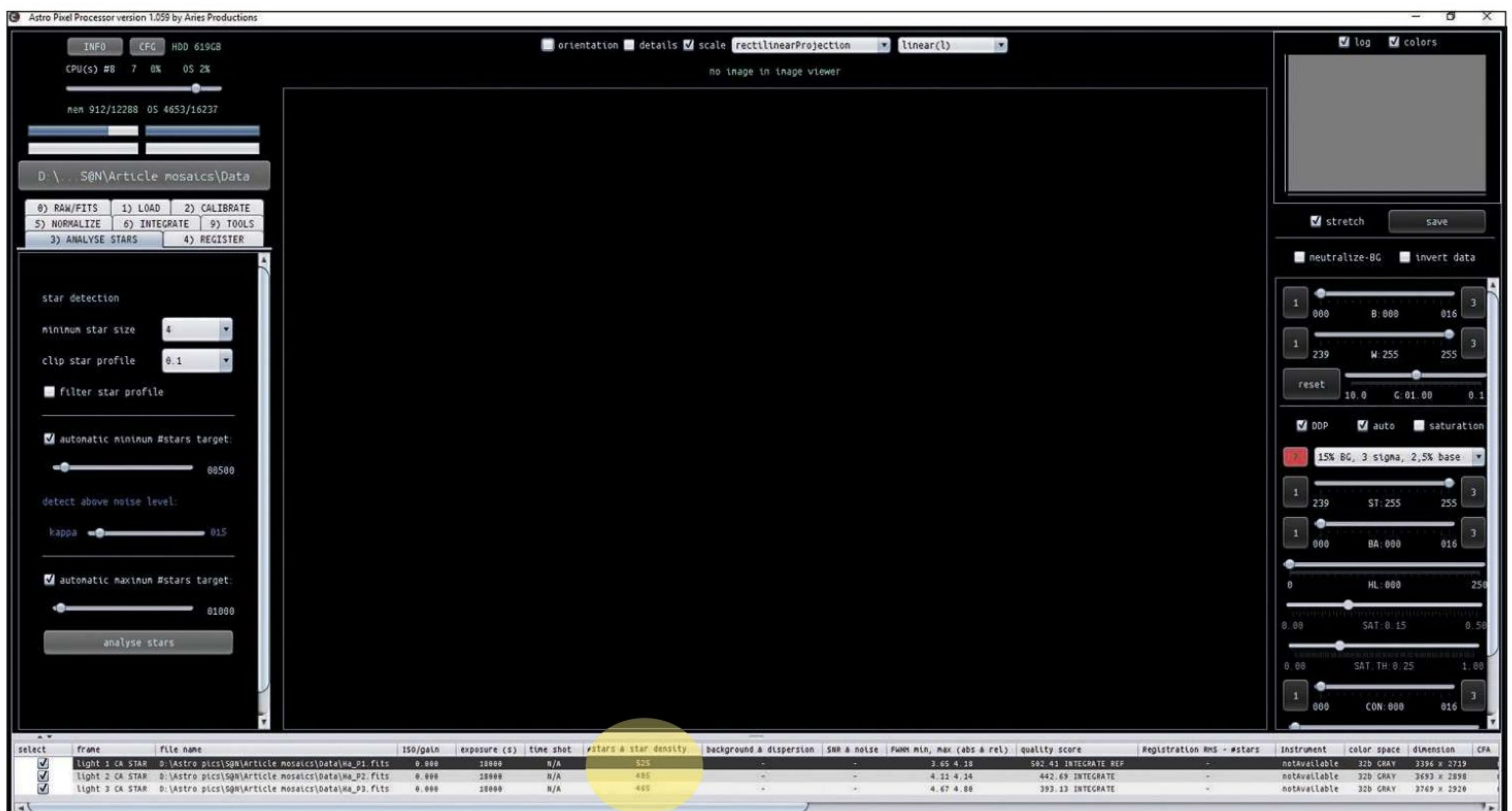
Above you can see the three panes that we’re going to stitch together. They’ve been given an auto stretch purely for illustrative

purposes. There’s a sufficient overlap to allow for accurate stitching.

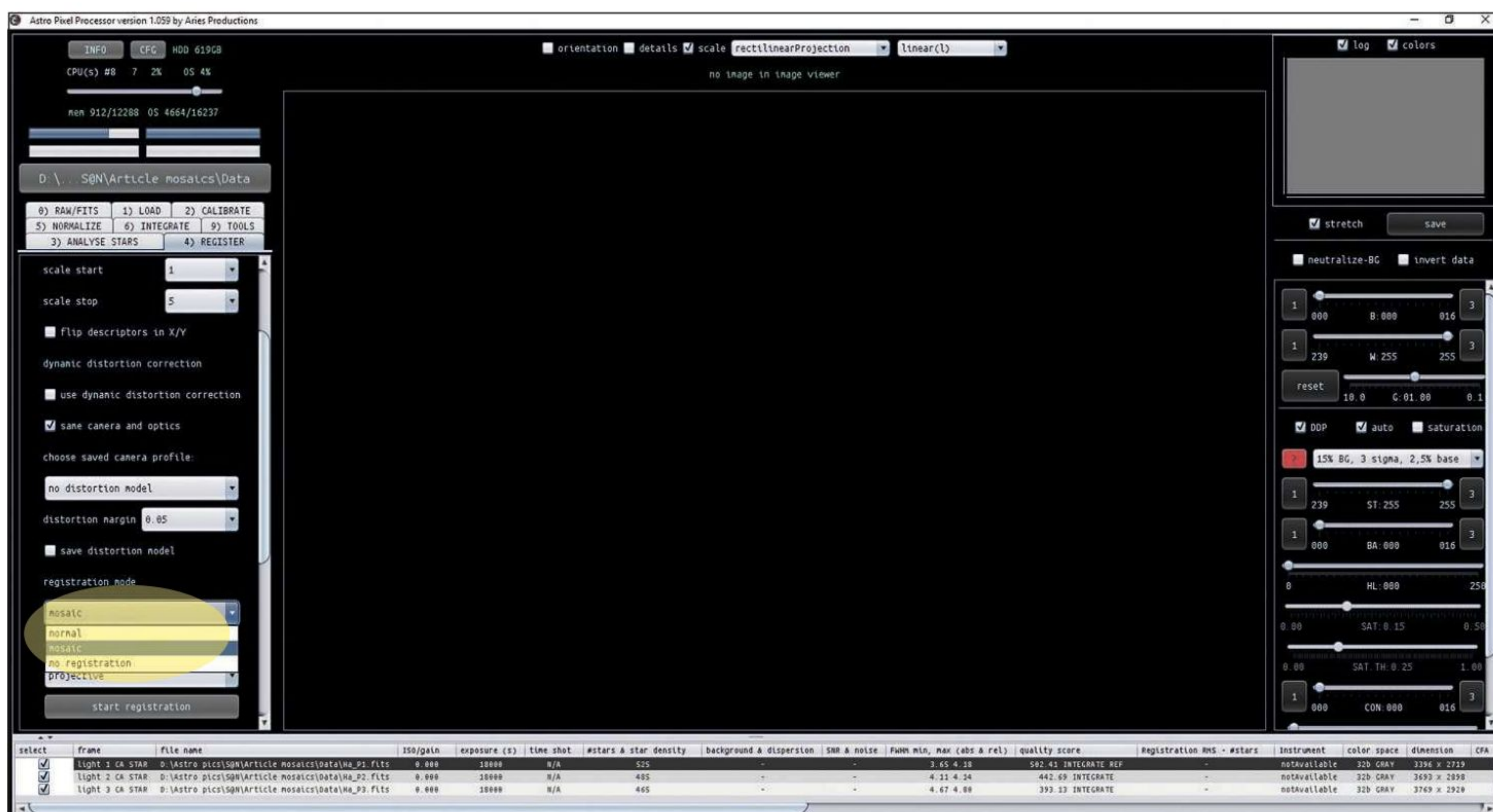
Load and analyse

Open APP and load your light frames by selecting the ‘LOAD’ option from the left-hand menu, then ‘light’ and selecting them from wherever you have them saved on your computer. As these frames have been calibrated there are no other images you need to load. Now click ‘3) ANALYSE STARS’ then the ‘analyse stars’ button that appears at the bottom of the left-hand menu and ensure that you have a good number of stars in the lower console. If there is not a sufficient amount (which you won’t know until you begin to stitch your mosaic) you may need to lower the Kappa settings in the ‘ANALYSE STARS’ menu and click ‘analyse stars’ again.

Click ‘4) REGISTER’ and ensure that you scroll down to ‘registration mode’ and in the drop-down menu select ‘mosaic’. Now ▶



▲ When it comes to the ‘ANALYSE STARS’ stage, you need to make sure that there’s a sufficiently high number of stars to analyse



▲ When it comes to the “REGISTER” step, you need to make sure you’ve selected ‘mosaic’ in the ‘registration mode’ drop-down menu

“If you want to combine different channels to create a colour image make a mosaic of each channel”

► click the ‘start registration’ button and three boxes pop up in turn. First, ‘disable “same camera and optics”’ – click ‘no’ in this instance. Second, ‘Increase “scale stop” for mosaic mode’ – click ‘yes’. And finally, ‘enable “dynamic distortion creation”’ – click ‘yes’ again. The registration process now takes place. Nothing changes in the lower console at this stage.

Click ‘5) NORMALIZE’ and select ‘advanced’ from the first drop-down menu. This will give you a better, more balanced result across the mosaic, especially for nebula. Click ‘normalize lights’.

Click ‘6) INTEGRATE’. This provides a number of options that will benefit from some experimentation. The ‘Local normalization correction’ menu can be changed to obtain more even matching of the mosaic frames. We will use ‘2nd degree LNC’ in the ‘LNC degree’ menu and ‘3 LNC iterations’. In ‘Multi-band blending’ tick ‘enable MBB’ and move the slider to ‘10%’. This will help to even out the edges that can occur between each individual pane as it is merged.

No outlier rejection is needed as the outliers have already been dealt with in the

previous integration to get the stacks of data. If this is used at this stage it could reject the very stars that we are using to match the panes. Leave everything else at default and click ‘integrate’.

Joined up

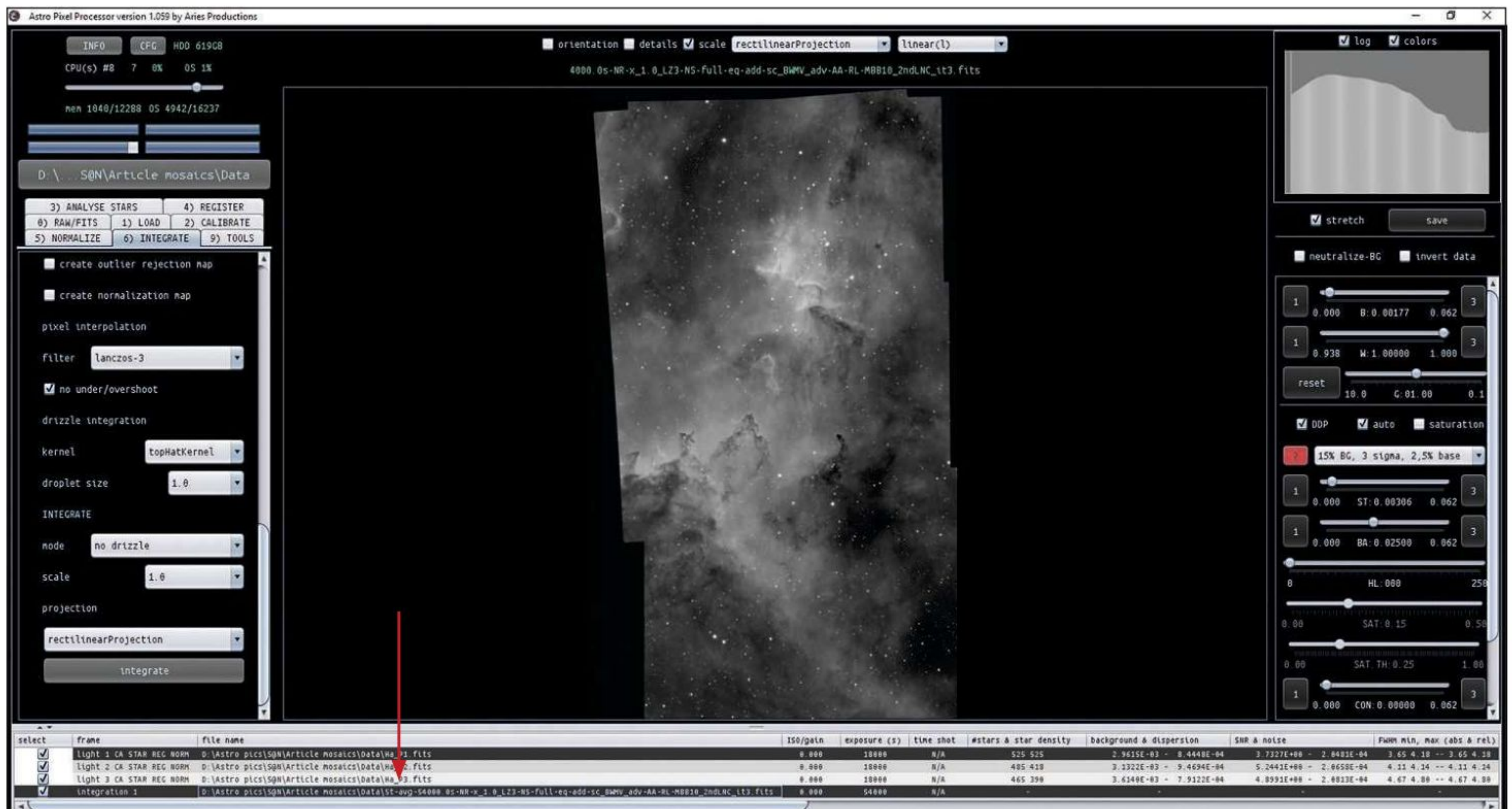
In the lower console you can now click on the integrated image and the stitched-together mosaic shows in the middle screen. This has a temporary stretch so that you can see the results. You can scroll around the mosaic by holding down the left mouse button to check that there are no visible joins.

If you want to combine different channels to create a colour image then we recommend that you make a mosaic of each channel individually as per this tutorial then combine them individually after that. Trying to put all of the data from all of the individual filters into APP does work, but it’s a very long process. Working on each filter individually is much more time efficient. **S**

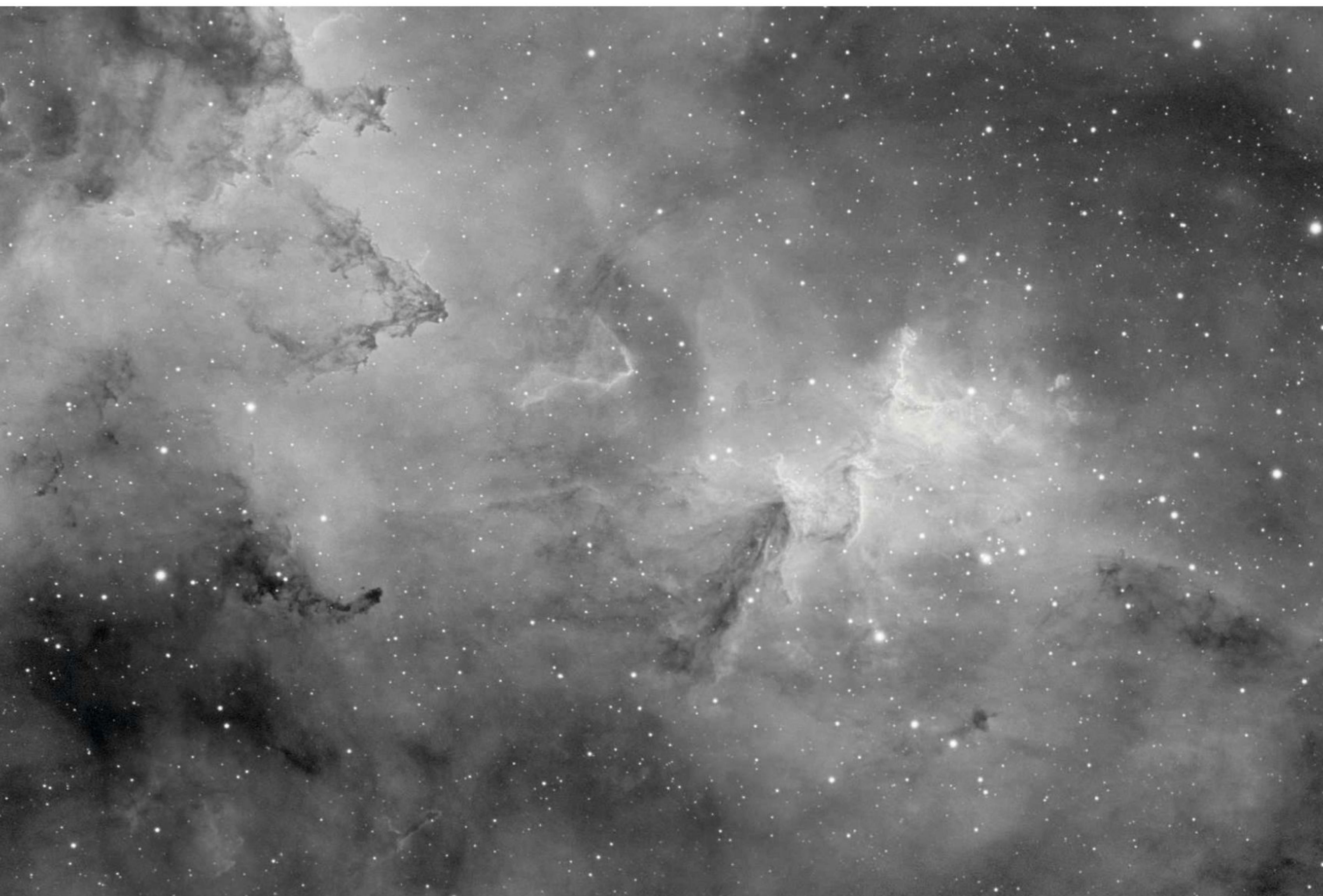
SARA WAGER is an expert at imaging nebulae in narrowband

Here’s the final stitched-together image





▲ After integrating, click on the integrated image in the lower console so that you can give the results a close inspection



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Scope DOCTOR



With
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Richards**

Our equipment specialist cures your optical ailments and technical maladies

I want to upgrade my Celestron AstroMaster EQ130 to a scope with a motor drive to improve my deep-sky photography. My budget is £1,000. Is a self-tracker or manual the best option?

The Celestron AstroMaster EQ130 is a good telescope for observing but the relatively lightweight, manually operated mount is not suitable for deep-sky imaging. For deep-sky imaging, the mount is the most critical element because the long exposures required to capture detail in these dim objects require a sturdy mount that tracks very accurately. I would urge you to invest in a suitably heavyweight mount like the Sky-Watcher HEQ5 Pro Go-To or Celestron Advanced VX mount.

Astrophotography has a steep learning curve but you can ease the pain by treading the well-worn path of using a Sky-Watcher Evostar 80ED DS-Pro refractor and focal reducer, but this will take you over budget. I'd be reluctant to recommend anything below this specification if you want to be sure of achieving good results with the minimum of hassle.

On the other hand, if you wanted to really push the budget and go for a true apochromatic refractor then both the William Optics GT-81 and William Optics Star 71 II (which also

incorporates a field flattener) should definitely be on your shortlist.

Unfortunately, your EQ130 Newtonian reflector will not achieve focus with a DSLR camera unless you use a Barlow lens, which increases the magnification, and that's something you don't want for many deep-sky objects. As an alternative, you could physically modify the telescope by moving the primary mirror towards the front of the optical tube to move the focal plane further outside the focuser.



◀ The Sky-Watcher HEQ5 Pro mount (pictured) or a William Optics GT-81 refractor are solid entry-level scopes for deep-sky imaging



▲ Built to last – the Sky-Watcher Esprit 150 ED

I would like a telescope I can use with my EOS 7D and laptop. I'm looking for longevity rather than low cost, perhaps something upgradable. Any suggestions?

A good quality imaging telescope requires a good quality mount to support it and if you want this to be a one-time-only purchase then you should aim for a heavy-duty mount with excellent tracking abilities for future proofing. Mounts that would fit this bill well would include the 10 Micron GM1000 HPS, the Mesu Mount 200 and the Paramount MyT. Any of these mounts will stand the test of time and never require upgrading.

For longevity and reliability, it is difficult to beat a good refractor as they don't require collimation. The Sky-Watcher Esprit 150 ED Pro or the Tec 140 with a suitable field flattener would be excellent choices but you could also consider the Takahashi FSQ-106ED which doesn't require a field flattener because of its modified Petzval design. Upgrades would include focusers although a more suitable cooled camera should be high on your shortlist.

STEVE'S TOP TIP

Why do I need polar align my equatorial mount?

Earth takes 24 hours to complete one revolution on its axis with regard to the Sun. However, because Earth also orbits the Sun, it takes 23 hours 56 minutes and 4.1 seconds to complete one revolution with regard to the stars. From an observer's point of view, the stars appear to move across the sky in an arc from east to west in the northern hemisphere and from west to east in the southern hemisphere. Therefore, to follow this movement it's necessary for the mount to rotate in the same plane as Earth by aligning it with the north and south poles.

STEVE RICHARDS is a keen astro imager and an astronomy equipment expert

Email your queries to scopedoctor@skyatnightmagazine.com

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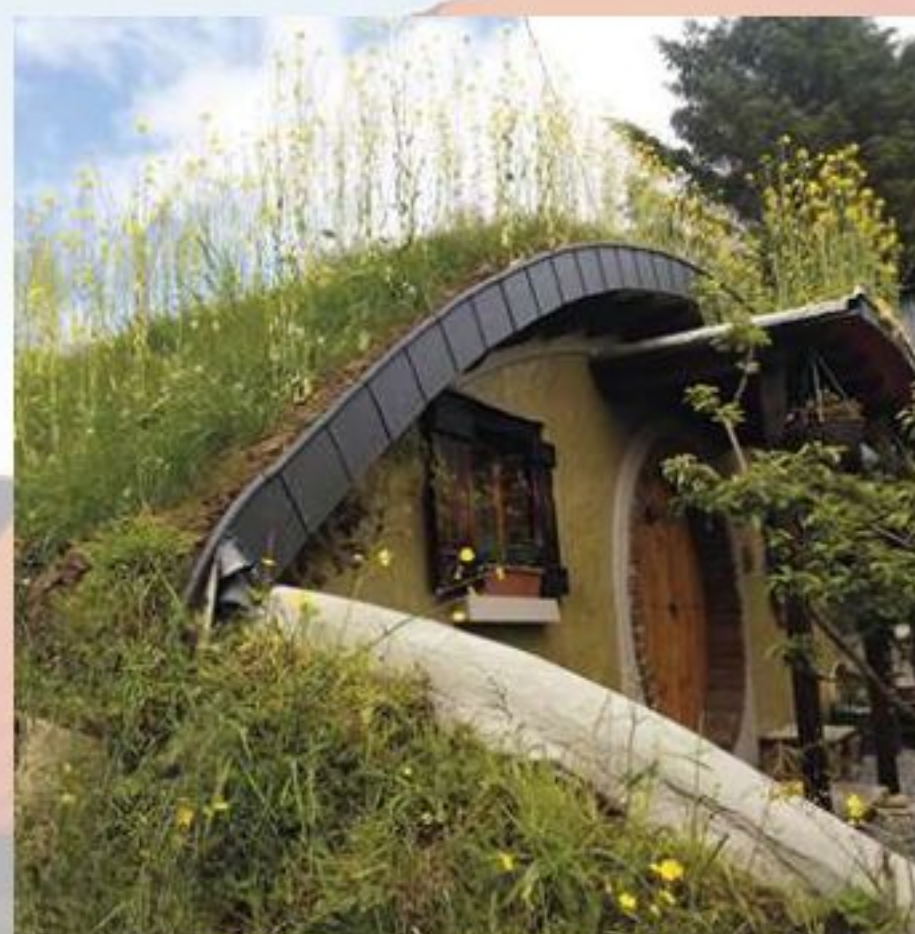
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Sky at Night
MAGAZINE

Reviews

Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

- ★★★★★ Outstanding
- ★★★★☆ Very good
- ★★★☆☆ Good
- ★★★☆☆ Average
- ★★★☆☆ Poor/Avoid

90

The Omegon Pro RC 203/1624 – a powerful Ritchey-Chrétien scope that won't break the bank, if you don't mind its stripped-to-basics ethic



SEE INTERACTIVE 360° MODELS OF ALL OUR FIRST LIGHT REVIEWS AT WWW.SKYATNIGHTMAGAZINE.COM



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Find out more about how we review equipment at www.skyatnightmagazine.com/scoring-categories

FIRST LIGHT

See an interactive 360° model of this scope at www.skyatnightmagazine.com/prorc203



Omegon Telescope Pro RC 203/1624

WORDS: TIM JARDINE

A low-cost Ritchey-Chrétien scope that's ideal for crisp astro imaging

VITAL STATS

- **Price** £799
- **Optics** Ritchey-Chrétien reflector
- **Aperture** 203mm
- **Focal Length** 1,624mm
- **Focal Ratio** f/8
- **Focuser** Dual-speed Crayford
- **Extras** Extension tubes and mounting rails
- **Weight** 6.2kg
- **Supplier** Omegon
- **Tel** +49 8191 940490
- **www.omegon.eu**

What telescope design might be best is a hotly debated topic among amateur astronomers. For professional observatories, including the Hubble Space Telescope, the preferred design is the Ritchey-Chrétien (RC). But the expense of constructing RC scopes typically rules this design out for amateurs. Recent manufacturing advances have reduced that expense, however, and so the design forms the heart of the Omegon Telescope Pro RC 203/1624.

Aimed at experienced or advanced amateur astrophotographers, the only extras this scope comes with are focuser extension tubes. We added a finderscope to help us star align the relatively long focal length telescope on our mount.

Although weighing a little over 6kg, the Omegon Pro RC feels quite hefty, owing to its short overall length and compact size. It took us a little while to determine the correct spacers to use and how to adjust the balance positions accordingly so that our

SKY SAYS...

Great views make the long-winded collimation process worth the effort

mount would perform at its best with the longish exposures required of an f/8 telescope.

With a clear sky forecast, we were keen to start taking pictures. But our first session with the Omegon Pro RC was spent ensuring that its mirrors were properly collimated, as the design demands perfect mirror alignment for optimal results. Amateur RC telescopes have a reputation for being difficult to collimate and the manual for this model, which we had to track down via an internet search, recommends you use additional accessories to make collimation easier, namely a laser and special eyepiece. We breathed a sigh of relief when the review telescope proved to be nicely collimated and hadn't become misaligned during delivery.

Working up to the whale

An ideal first target for this test was Messier 13, the Great Globular Cluster in Hercules. With a close-up view we hoped that the Omegon Pro RC's optics would provide a sharp image right to the core of the cluster, and we weren't disappointed. We took a ▶

Hyperbolic mirrors

Although invented over a century ago by George W Ritchey and Henri Chrétien, difficulties in accurately manufacturing hyperbolic mirrors for RC telescopes have generally made them too expensive for amateur equipment. But recent advances in optical measurement and manufacturing have meant that the mirror sets can be made much more economically today, allowing reasonably priced RC models to come onto the market. The RC mirror design eliminates the optical problem of coma – when star shapes towards the edges of the view become elongated – so typical of Newtonian telescopes. The Omegon Pro RC 203/1624 provides a flat-field of view over a full-frame (36x24mm) camera sensor and requires no front corrector plate like similar-looking Schmidt-Cassegrain telescopes do. In addition, the low-expansion quartz crystal mirrors are fixed in place and avoid issues such as mirror flop that can spoil images from a Schmidt-Cassegrain. Unlike some refracting telescopes, the Omegon Pro RC's mirror arrangement avoids colour aberration problems, making it suitable for DSLR and one-shot colour astronomy cameras. Such a pedigree perhaps makes the long-winded collimation process a worthwhile undertaking.



Solid build and construction

Solidly constructed from steel, with well-designed and reassuringly sturdy fittings inside and out, the tube measures just 580mm in length and 230mm in diameter. Ideal for a permanent observatory situation, it's also reasonably portable if required. The Allen key collimation adjustment screws are conveniently located on the front and rear.



Internal baffles

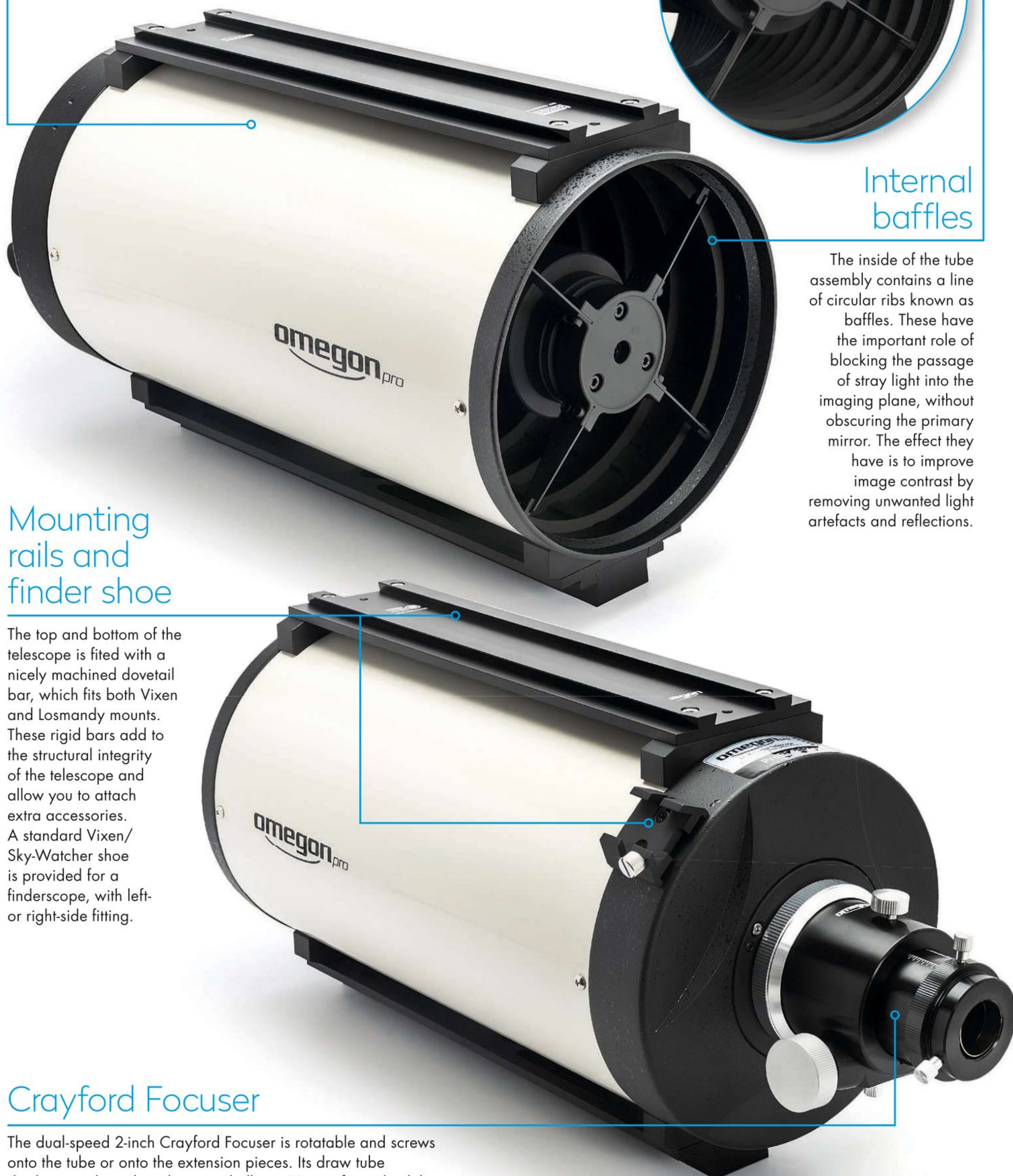
The inside of the tube assembly contains a line of circular ribs known as baffles. These have the important role of blocking the passage of stray light into the imaging plane, without obscuring the primary mirror. The effect they have is to improve image contrast by removing unwanted light artefacts and reflections.

Mounting rails and finder shoe

The top and bottom of the telescope is fitted with a nicely machined dovetail bar, which fits both Vixen and Losmandy mounts. These rigid bars add to the structural integrity of the telescope and allow you to attach extra accessories. A standard Vixen/Sky-Watcher shoe is provided for a finderscope, with left- or right-side fitting.

Crayford Focuser

The dual-speed 2-inch Crayford Focuser is rotatable and screws onto the tube or onto the extension pieces. Its draw tube displays graduated markings and allows 50mm of travel, while the large knurled lock nut is easy to operate, holding cameras well; we found no trace of focuser slop.



FIRST LIGHT

Extension tubes

The only additional items in the box are a pair of extension tubes, 1x50mm and 2x25mm. These are necessary to extend the focuser position to suit a wide selection of cameras, filter wheels and accessories. The internal diameter of these tubes is 80mm, avoiding any potential vignetting issues.



SKY SAYS...

Now add these:

1. Omegon Carbonline 2-inch, 90° mirror star diagonal
2. Omegon ADC atmospheric dispersion corrector
3. Omegon Camera Easy Autoguiding-Set60

► series of five- and 10-minute exposures, which revealed the full extent of the outer edges of the cluster, while maintaining distinct details and star colour at the bright core.

Encouraged by these results, our next targets included Messier 27 (the Dumbbell Nebula), M51 (the Whirlpool Galaxy) and the distinctively shaped Whale Galaxy, NGC 4631. When the first 15-minute exposure of the Whale appeared on screen it was one of those “Wow!” moments. The galaxy has a bright core along with nicely

defined dark dust lanes and is peppered with hints of star clusters and hydrogen-rich, star-forming regions, all of which were crisply captured by the precision optics of the Omegon Pro RC.

Acquiring and maintaining proper focus is a key requirement with astrophotography, especially so at longer focal lengths. We were pleased to note that the quartz mirrors in the Omegon held tight focus for long periods, even during temperature shifts of several degrees. The smooth Crayford focuser kept the target central during focusing and after locking it off. We used our 8-inch Bahtinov mask to assist with the focusing process, but we could have used the diffraction spikes from the rigid secondary mirror holder to good effect too.

As mentioned, RC telescopes are designed for photography; the relatively large central obstruction caused by the secondary mirror makes for a loss of contrast when used as a visual instrument. However, with Jupiter and the Moon situated nicely to the South, we did spend a couple of hours with eyepieces, enjoying some well-defined views, from 70x, up to 380x as the seeing allowed. We also took the opportunity to perform a high-magnification star test to check the collimation after several



▲ Above left: M13 taken through an Atik 460EX camera. Six hours' total exposure time made up of 5- and 10-minute exposures. Above right: M27, four-hour total exposure time made up of 10-minute exposures

◀ NGC 4631 also taken through the Atik 460EX. Seven-hour total exposure time made up of 15-minute exposures

nights of the scope being swung to positions all over the sky and were impressed to find that the optics were still properly aligned.

In summary, the Omegon Pro RC offers sharp, coma-free images at a focal length that allows the finer details of deep-sky objects to be revealed. **S**

Verdict

Build and design	★★★★★
Ease of use	★★★★★
Features	★★★★★
Imaging quality	★★★★★
Optics	★★★★★
OVERALL	★★★★★

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ROBIN SCAGELL

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Sark: Top 20 must-see "Best Trips 2015"

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FIRST LIGHT

See an interactive 360° model of this mount at www.skyatnightmagazine.com/skysolarquest



Sky-Watcher SolarQuest Solar Go-To tracking mount

WORDS: PETE LAWRENCE

A fast, simple and reliable system for keeping your scope pointed at the Sun

VITAL STATS

- **Price** £339
- **Mount type** Altaz
- **Power** 8xAA batteries or external power supply adaptor
- **Size** 150x150x90mm
- **Tripod size** 700mm (collapsed); 1,100mm (fully extended); 220mm extension pier provided
- **Weight** 1.3kg (mount head); 1.9kg (tripod)
- **Capacity** 5kg
- **Supplier** Optical Vision Limited
- **Contact** info@opticalvision.co.uk
- **www** opticalvision.co.uk

SKY SAYS...

An accurate, safe and easy-to-use way of locating and tracking the Sun, which is also very portable

Solar observing represents the less stressful side of astronomy. Working in plenty of light and frequently warm conditions, it's often a pleasurable experience. It does, however, share some characteristics with night-time astronomy. For example, you still have to find the Sun and – for maximum convenience and safety – use a tracking mount to keep it in view. This is something that the Sky-Watcher SolarQuest mount is specially designed to help you with.

Finding the Sun during the day might not sound like the most demanding task, but precise telescope alignment can prove surprisingly tricky and it's essential to use a method that doesn't mean you have to look at the Sun with unprotected eyes.

The SolarQuest mount performs the task automatically. The mount includes a stable, lightweight tripod and an L-shaped solar tracking mount head. It's powered by eight AA batteries but these can be swapped for an external power supply adaptor if required (although we were unable to test this out as the adaptor was not available at the time of review). A power button and an eight-way slider switch provide the remaining controls.

Sun seeker

The supplied tripod has a 220mm extension pier that allows long instruments to swing round without hitting the tripod legs. The tripod and mount head also have built-in spirit levels for levelling. Once you've attached your solar telescope, all that remains to be done is to turn the mount on. After a short delay, the mount acquires a GPS positional fix, the date, the time and the position of the Sun. The mount then moves the scope so that it points directly at the Sun. A solar sensor helps refine and maintain position. From pressing the power button to getting the Sun in view takes around 60 to 90 seconds on a clear day.

The first time you use your own telescope, a one-time calibration is required. This requires you to power off, press the eight-position switch to the upper-left position, power on and finally power off ▶

Convenience and accuracy

We were very impressed with the SolarQuest mount. It's so simple to use and performed very accurately in our trials. It alleviates the need to polar align during the day, something which can't be done with precision unless you have a permanent set-up. In this respect it suits casual solar observing well but really excels for things like public events where there are typically a lot of eager viewers wanting to take a peek at the Sun. Eliminating the need for constant repositioning, the SolarQuest makes setting up for such events a breeze.

Most personal solar observing sessions last less than an hour and we found that the unit would hold a very accurate position for far longer than this. Exceptions may occur if, for example, you were using an H-alpha telescope and monitoring for flare activity. This would normally be done by setting up the telescope and watching for increases in X-ray output from sources such as the GOES X-ray satellite. Here, the ability to have a quick and simple mount tracking accurately for extended periods would be incredibly useful.





Sun sensor

The mount head relies on a GPS signal to obtain its position and time fix. Once this has been done the internal computer can work out where to point the head to get the Sun in view. A solar sensor is used to confirm and maintain an accurate position. Clouds inevitably reduce the mount's pointing accuracy.

Mount coupling

The top of the SolarQuest's tripod has a standard male 3/8-inch tripod screw, which is designed to couple with a female thread on the base of the SolarQuest mount. Of course, this also means that you're free to attach the SolarQuest to your own tripod should you want to.

Tripod

The SolarQuest mount ships with a sturdy and lightweight tripod. Fully extended it is 1.1m in height, but this can be further extended by a 220mm extension pier. An accessory tray clips into position, which also provides additional stability to the tripod. The legs extend via rotating collar locks allowing the tripod to be deployed quite rapidly.

FIRST LIGHT

► again. The initial pointing accuracy may be off slightly but is easily corrected using the eight-way slider. Once done, the correction can be stored by simply double-pressing the power button. This technique can also be used to move between areas of interest on the Sun's disc. It's worth noting that a mount purchased with a Sky-Watcher solar telescope is normally pre-calibrated at the factory.

The SolarQuest is elegant in its simplicity and works like a dream. For one of our review tests we fitted a small, white light-filtered telescope onto the mount head, powered the SolarQuest mount and waited for it to point at the Sun. Once done, we fine-tuned the Sun's position via a high frame-rate camera and an on-screen reticule. We checked the alignment at regular intervals and, impressively, over a five-hour period the Sun's disc remained within the central part of the reticule.

Accuracy issue for large scopes

When using larger and heavier scopes with naturally longer focal lengths, we found that long tracking periods could introduce a small drift in position. This may be down to incorrect altitude scope balance but as the altitude axis is not free running on this mount, it's difficult to get this totally accurate. For a typical solar observing session, it wouldn't be too much of an issue.

The SolarQuest is an altaz mount and doesn't naturally mirror the true equatorial motion of objects as they appear to move across the sky. The on-board computer emulates equatorial motion extremely well but can't overcome the issue of field rotation. This effect will cause the Sun's disc to rotate with respect to the eyepiece or camera frame over time and will make orientating your view of the Sun that little bit trickier. While attempting a two-frame mosaic of the whole Sun in white light, there was a slight but nonetheless noticeable rotation between frames that had to be adjusted post capture.

Apart from this issue, the SolarQuest mount does its job superbly and is really easy to use. There are plenty of solar telescopes below its 5kg limit giving you the opportunity to create what could be a dream combination for convenient and portable solar observing. **S**

Dovetail

The solar telescope is attached to the side of the mount via a Synta/Vixen-style dovetail clamp. As long as the telescope is kept under the 5kg load capacity of the mount, the clamp's single locking knob will hold its payload with enough rigidity to avoid any unwanted motion in the telescope's position.

Control panel

The SolarQuest has two controls; a power button and an eight-position switch. The switch is used for pointing corrections, calibration and factory reset operations. Changes to settings can be saved using a double-press of the power button. Two status lights indicate the power and tracker status of the mount.



SKY SAYS...
Now add these:

1. A suitable white light solar telescope
2. A suitable H-alpha solar telescope
3. A 7Ah power tank

Verdict

Build and design	★★★★★
Connectivity	★★★★★
Ease of use	★★★★★
Features	★★★★★
Solar tracking/guiding accuracy	★★★★★
OVERALL	★★★★★

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FIRST LIGHT

See an interactive 360° model of this camera at www.skyatnightmagazine.com/BresserFullHD



Bresser Full HD Deep-Sky Camera

WORDS: GARY PALMER

Premium pixel power plus versatility make this a decent beginner's choice

VITAL STATS

- **Price** £231
- **Sensor** Sony Exmor IMX290 CMOS
- **Sensor size** 6.46mm diagonal
- **Pixels** 1,936x1,096 (2.1MP)
- **Pixel size** 2.9x2.9µm
- **Ports** USB2 and ST4 guide port
- **Extras** C-mount adaptor, 200cm USB 2.0 PC connecting cable, 150cm interface cable for ST-4 autoguider port, dust cap, software CD
- **Weight** 90g
- **Supplier** Telescope House
- **Tel** 01342 837098
- **www.telescopehouse.com**

Sony's IMX290 sensor has proven popular since its launch into the astronomy market and now Bresser has introduced its Full HD Deep-Sky Camera to take advantage of its impressive specs. The camera uses the USB 2.0 format for downloading images to your laptop and the camera is aimed at planetary, lunar and some basic deep-sky imaging. With a built-in guide port it can also be used for autoguiding and comes supplied with a 1.25-inch nosepiece, ST4 guide cable, USB 2.0 cable and a software CD.

At first glance the camera has the generic form of other cameras on the market. What helps differentiate it is the clear glass in front of the sensor instead of IR glass. This means the camera will need a UV/IR-cut filter when imaging planets and the Moon. Once the software and drivers are installed the camera can be used with the ToupSky image capture and processing software.

Using the full resolution in planetary mode the camera will run at around 20fps. Using Region of Interest (ROI) you can obtain a higher speed, but since it relies on USB 2.0, you can't really call it a

SKY SAYS...

Despite issues working with any software other than ToupSky, this is a great all-round camera

high-speed camera now that USB 3.0 is becoming standard.

The manufacturer states that the camera can be used with other popular capture software, however a couple of test runs in SharpCap and FireCapture revealed it wasn't quite as easy as they say. There are two ways to connect the camera under settings in SharpCap. The first is using the ASCOM driver.

The problem is that the camera can only run in RGB24 and not RAW 8 or 12-bit modes. This can cause all sorts of problems with colour and rings around planets. You also can't take good deep-sky images in that setting. While an ASCOM driver is included in the software, it seems the RAW drivers have been left out. The other way of connecting the camera is to use a driver from another manufacturer which does allow the camera to run in RAW mode. This means we could only get the camera to image properly in the ToupSky software supplied.

Concentrate on the details

To image the Moon we first set the camera up on a 4.5-inch refractor. The picture on screen was very good, containing lots of detail. With the camera set in 8-bit mode and RAW, the image had a green cast ▶

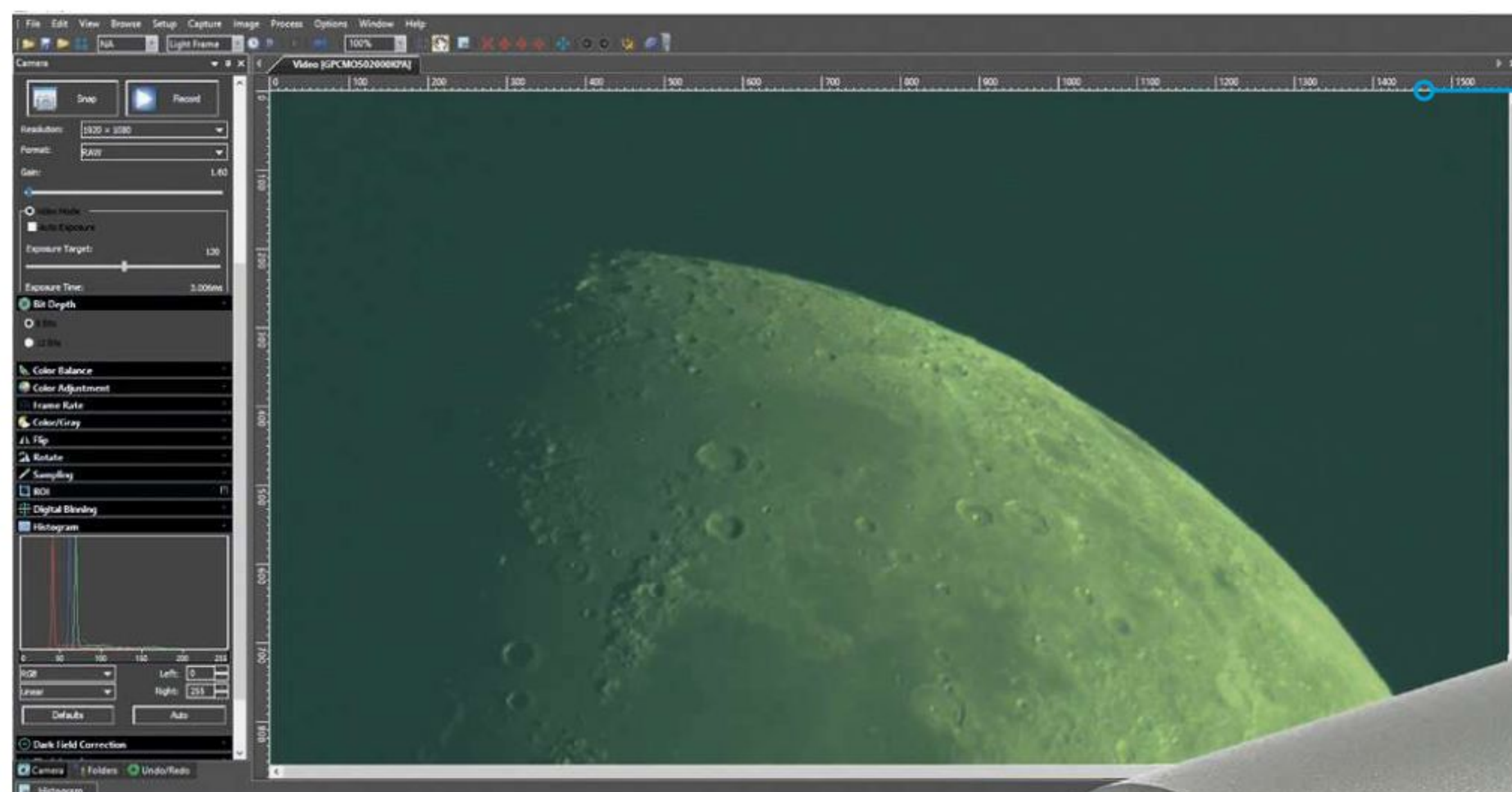
IMX290 CMOS sensor

The IMX290 colour sensor is highly sensitive to faint light and has extremely low read noise. While it carries a faint amount of ampglow this is easily countered by using dark frames taken along with the light frames. With a sensor size of 1,936x1,096 and a pixel size of 2.9µm the camera can image a range of targets on modest equipment, making it a quite versatile device and ideal for those just starting out in astrophotography. If the camera is connected to larger aperture equipment you can use lower magnification in planetary and lunar imaging thanks to its pixel size, particularly helpful considering the ever-changing seeing conditions in the UK. Sony's IMX290 sensor has a full range of ROI settings to help frame any object, so for planetary imaging you can use a smaller region to achieve a higher frame rate. The sensitivity of the sensor allows you to do short exposure deep-sky imaging and helps with imaging setups that don't have an accurate polar alignment or guiding facility.



Software

A software CD included in the box contains Bresser's TouPSky software, ASCOM and camera drivers. This is handy when you're setting the camera up, especially if you have no access to an internet connection. The software is compatible with Windows 7, 8 and 10, Mac OSX and Linux.



Camera body

The camera has an aluminium body with internal connections that allow for the air around the camera to cool the sensor. Another benefit of the body design is that it allows the camera to be used on a lot of solar equipment without the need for a Barlow to be attached to the front.



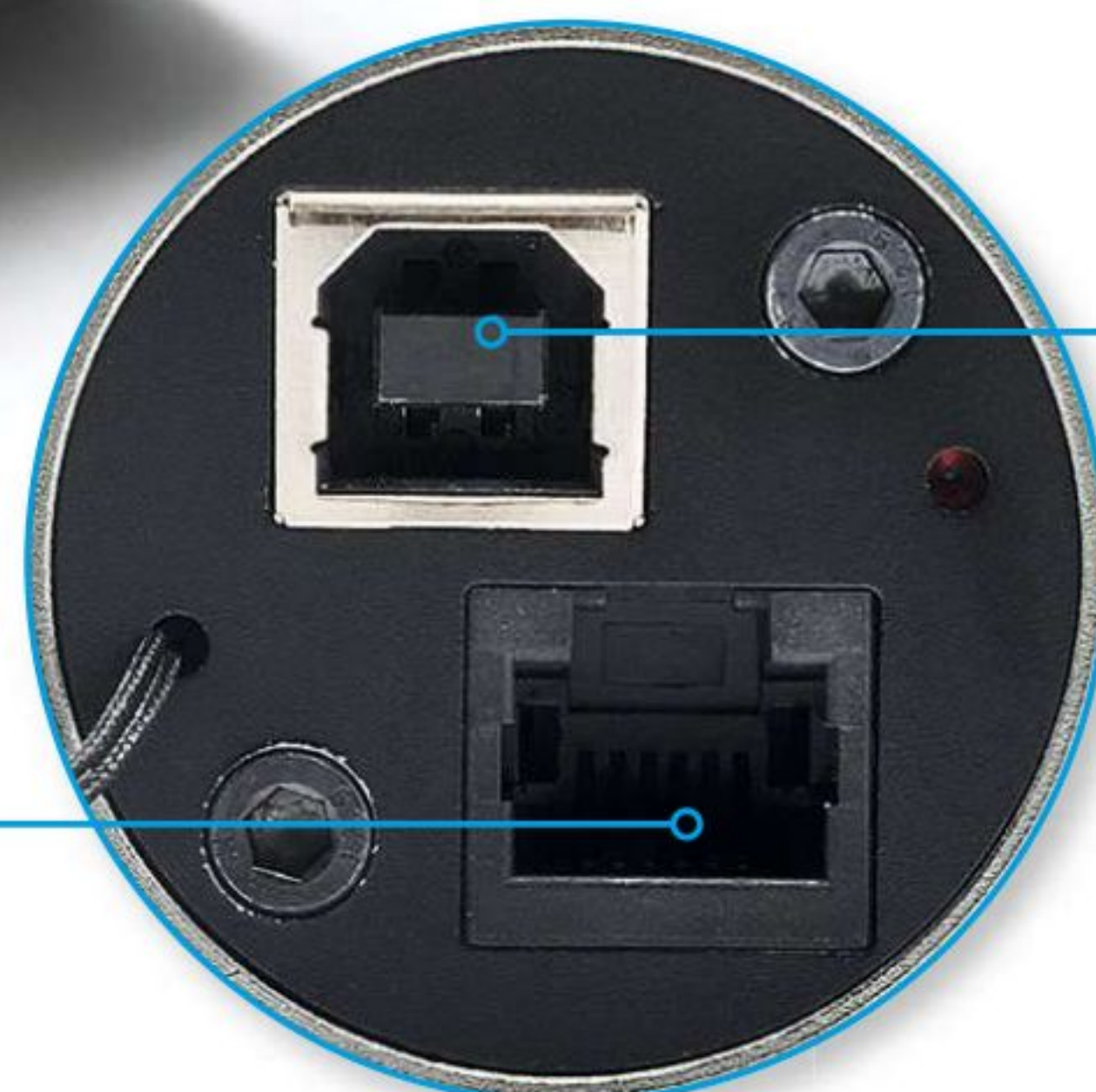
USB 2.0 port

Using the USB 2.0 format means the camera can be connected to an array of USB hubs and USB extension leads.



Guide port

The camera has an ST4 guide port which means it can be used to guide the most popular mounts on the market. This also allows it to be used with popular guiding software like PHD1 and 2. The tubular design of the camera allows for it to be mounted on a range of guidescopes.



FIRST LIGHT

C-mount adaptor

The camera can be connected to an array of equipment via the included the C-mount adaptor. This allows you to screw filters and reducers to the front of the camera. If the camera is connected to an optional M42-to-C-mount adaptor, it can be fitted to a filter wheel or a large format Barlow.



SKY SAYS...

Now add these:

1. Revelation 1.25-inch IR filter
2. Orion 30mm ultra-mini guidescope
3. Explore Scientific 3x Barlow 1.25-inch focal extender

► like most other cameras. This is due to the sensor's Bayer matrix layout containing more green pixels. However, this can be easily balanced out during post processing.

Our next target was Jupiter. Unfortunately, the seeing conditions didn't allow us to use a larger aperture telescope so we continued with the 4.5-inch refractor and a 4x Powermate. On the control panel there is a check box for region of

interest (ROI). With this checked you can draw a small box around

Jupiter and remove the area you don't want to image, which allows the camera to work at a higher frame rate. The resulting images were very good for the equipment being used, with lots of detail.

We then chose M27 as a deep-sky object to image using the Live Stack feature in ToupSky. By covering the telescope and taking some dark frames using the dark field correction tab you can subtract the darks for live stacking. ToupSky also contains a trigger mode for long exposure. When imaging in long exposure mode you need to make sure the RAW mode tab is selected. Finally, although we generally don't use colour cameras for solar imaging in H-alpha, we used the Bresser on a Lunt solar scope and got some quite interesting detail of the Sun.

Overall, a decent camera for imaging a large range of targets with the ability to image solar, lunar and deep-sky objects using the proprietary software. **S**



A mosaic of the Moon, created from five panes, through a 4.5-inch refractor

Jupiter imaged using a 4.5-inch refractor and a 4x Powermate



▲ M27 imaged using Live Stack mode in ToupSky



◀ Solar filaments captured with a Lunt Solar telescope

Verdict

Build and design	★★★★★
Connectivity	★★★★★
Ease of use	★★★★★
Features	★★★★★
Imaging quality	★★★★★
OVERALL	★★★★★

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Photo: Oliver Edwards

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Books

New astronomy and space titles reviewed

RATINGS

- ★★★★★ Outstanding
 ★★★★☆ Good
 ★★★☆☆ Average
 ★★☆☆☆ Poor
 ★☆☆☆☆ Avoid

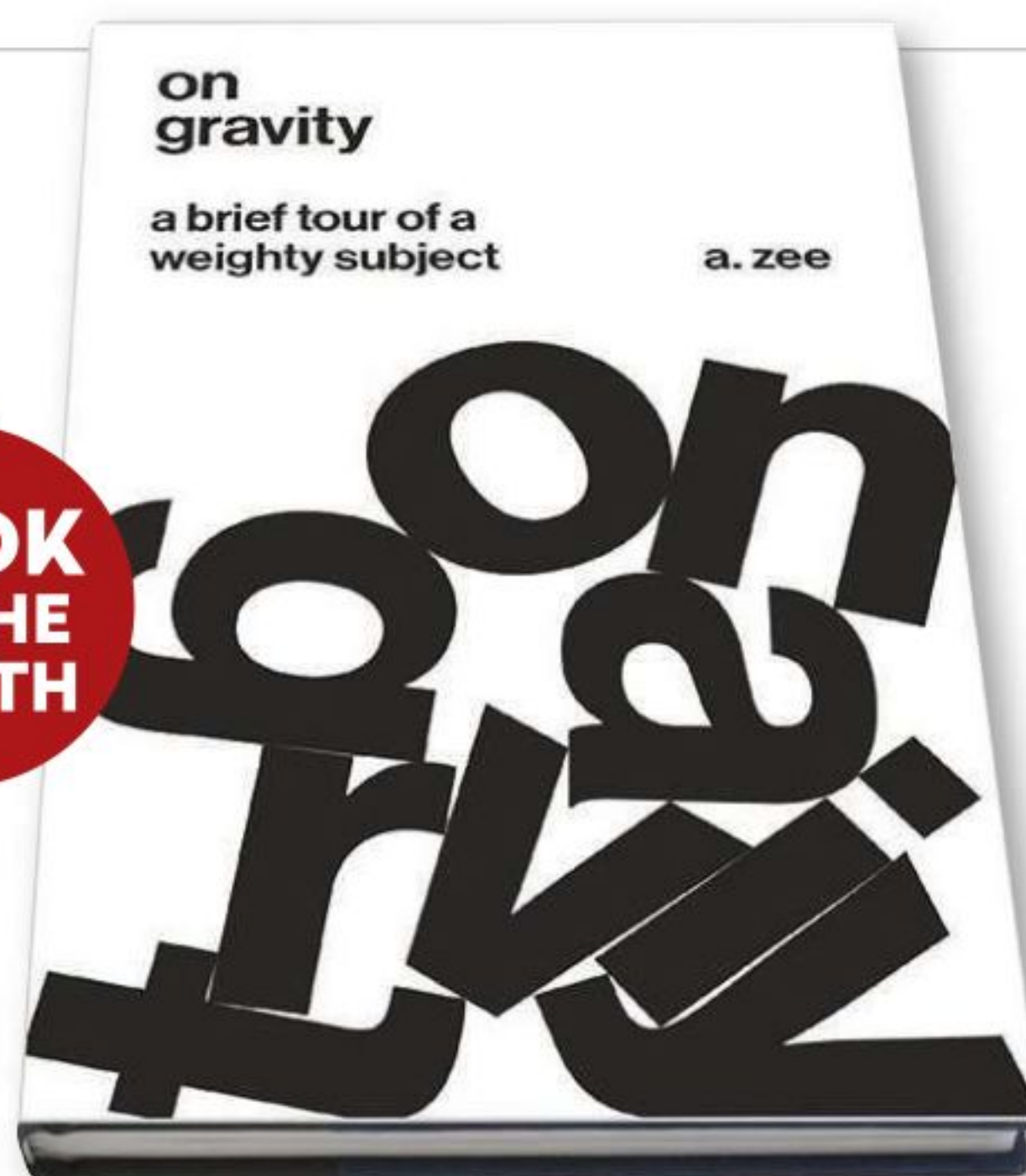
On Gravity: A Brief Tour of a Weighty Subject

A. Zee
 Princeton University Press
 £14.99 • HB

'Gravity' is a word that inspires much curiosity, because it's something we're all intimately familiar with and it shapes our every day. Few of us, however, have been fortunate enough to study gravity, but I would argue there is a yearning in each of us to better understand it (although I would never be so bold as to say I understood it fully).

Down the pub, I'm often asked to explain what gravity is. My fellow patrons brace themselves in anticipation of the confusion and maths they're expecting to be thrown at them. Next time I'll be handing (not throwing) them A. Zee's *On Gravity* instead.

In Zee's own words, this book aims to, "bridge the gap between popular books and textbooks on Einstein gravity". It very successfully does this. The author guides us with ease through the development of crucial concepts that lead to Albert Einstein's Theory of General Relativity. Zee starts with the discovery of gravitational waves, then takes the reader on a complete tour of gravity to understand how they come about. On the way you'll learn how gravity compares to electromagnetism, how spacetime curves and how binary stars fit into everything, and that's just a few of the concepts explored in the book. Zee also spends time on black holes, Hawking radiation and



BOOK
OF THE
MONTH

gravitons, as well as teasing the reader with insights on quantum gravity.

The book is wonderfully concise and Zee has an engaging and entertaining prose style. At times I felt as though I was sitting in Zee's office, listening to him explain and digress on a topic he's clearly passionate about. I thoroughly

recommend flipping to the notes section at the back while reading the book

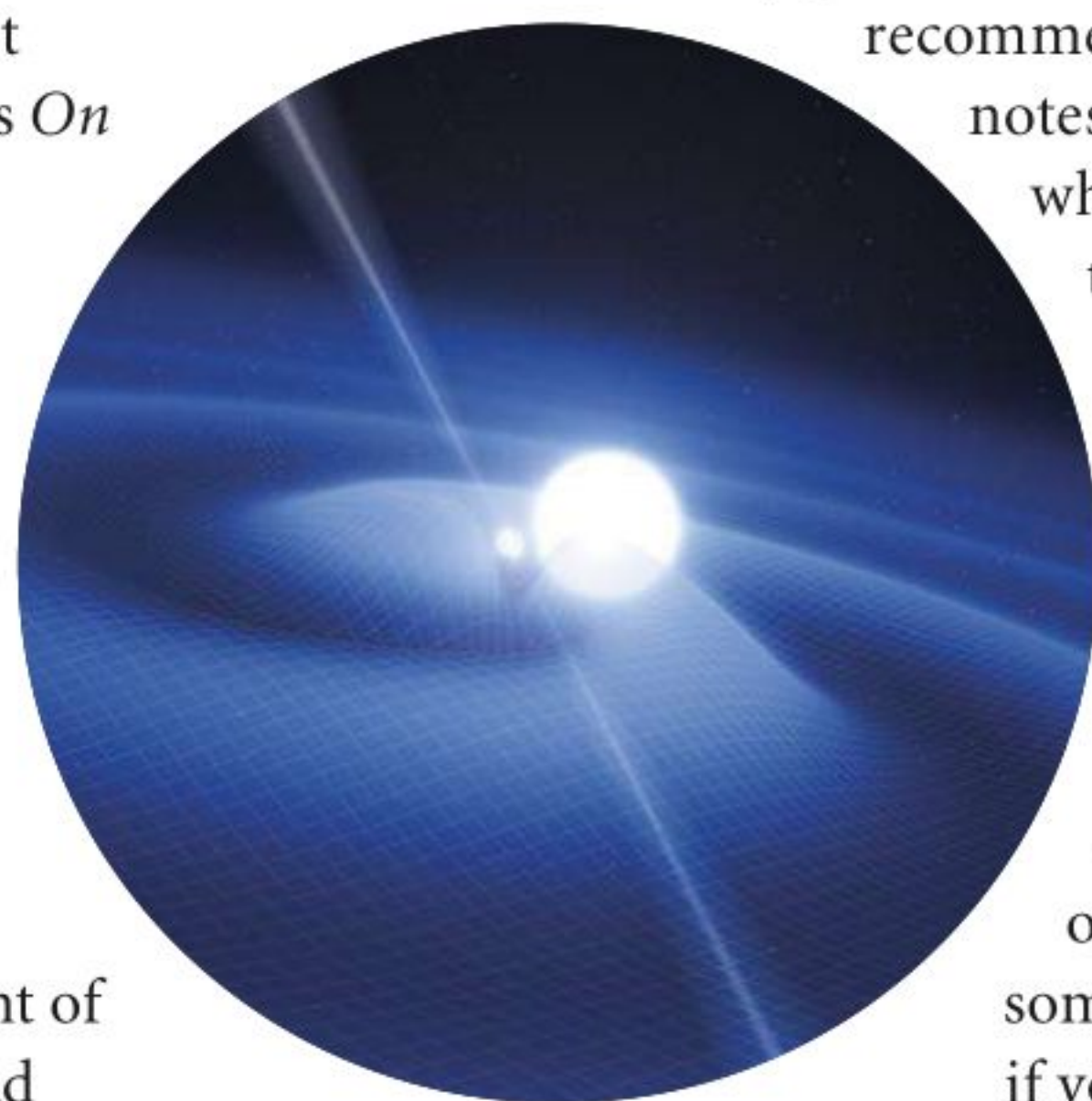
to capture all of those meandering thoughts. The layout impresses, too. Each concept is separated into digestible sections spanning a page or two. There's even some maths, although if you blink you may well miss it.

I would certainly recommend Zee's

witty book to anyone who wants to understand more about the weird and wonderful concepts of gravity.

★★★★★

DR LAURA NUTTALL is a *Sêr Cymru* MSCA COFUND fellow at Cardiff University and a member of the LIGO Scientific Collaboration



"Gravity is a habit that is hard to shake off." Terry Pratchett

TWO MINUTES WITH A. Zee



What is gravity?

Aristotle: Earth is the natural home for rocks. Rocks fall because they want to go home.

Newton: That Aristotle fellow is full of baloney. I've interviewed many rocks, and they've never mentioned going home. Rocks and apples fall because they and Earth attract each other.

Einstein: The force Newton talks about results from the curvature of space and time, which, by the way, are just two aspects of spacetime.

Quantum gravity theorist: Einstein's curved spacetime is due to gazillions of gravitons sashaying around.

(Ignore Aristotle – the other three are all speaking the truth.)

Why was the detection of gravitational waves such an important event?

The Universe is putting on a sound and light show: a gravity and electromagnetic wave show. But until 2016, it had been like a silent movie. Suddenly, the sound was switched on. Exciting!

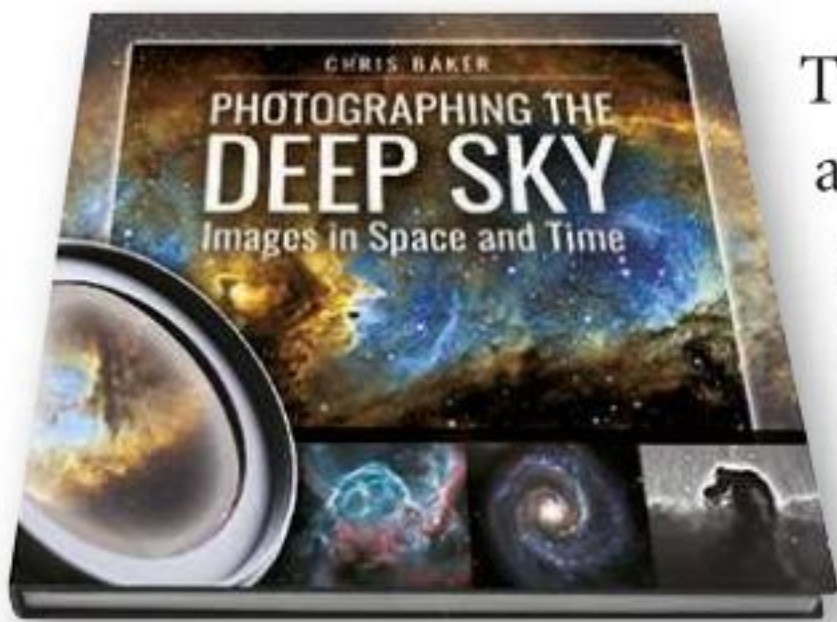
What are the biggest mysteries surrounding gravity we've yet to learn?

Newton's theory suffices for almost all practical purposes, and Einstein's for cosmic purposes, but theorists long for quantum gravity, in which curved spacetime is constantly fluctuating. While for some the teeth-gnashing search is not so much a practical necessity as a 'moral imperative', other physicists, notably the eminent British-American theorist Freeman Dyson, are not in the least bothered by the failure to quantise gravity.

A. ZEE is professor of physics at the Kavli Institute for Theoretical Physics at the University of California, Santa Barbara

Photographing the Deep Sky: Images in Space and Time

Chris Baker
White Owl
£25 • HB



This is not a book about astrophotography, but about light. Trapping the light from deep-sky delights and

setting them out in order of how far away from the Solar System they are, noted astrophotographer Chris Baker presents over 60 stunning full-page images in the context of space and time.

The book opens with his fabulous image of the Pleiades star cluster at 440 lightyears away and ends with the galaxy cluster Abell 2065 at over a million lightyears distant. Baker's photos are split between images from within the Milky Way and images from beyond our Galaxy.

It's difficult to pick the best images, but his Bubble Nebula and his colleague Sara Wager's blisteringly detailed Orion Nebula are both stunning, as is Baker's side-on spiral galaxy NGC 4565 and the M13 globular cluster in Hercules. The images get pride of place, of course, but a chapter describing what Earth was like when the light of these objects started its journey to his camera adds a powerful sense of 'deep time' to the deep sky.

The author's observatory is in Spain, which necessarily ignores the deep sky as seen from the southern hemisphere. Perhaps Baker could have inserted a 'northern hemisphere edition' subtitle to make that clear.

However, it's impossible not to deeply admire Baker's book not only for its mesmerising images, but for its creative yet sensible structure and its clear, concise explanations. It all contributes to this coffee table-style book giving Chris Baker's jaw-dropping astrophotography plenty of room to shine.

★★★★★

JAMIE CARTER is the author of *A Stargazing Program for Beginners: A Pocket Field Guide*

The Spinning Magnet

Alanna Mitchell
Oneworld
£16.99 • HB



Could all life on Earth be wiped out by the simple spin of a magnet? This book delves into our planet and its history to find out. The author weaves a story of scientific curiosity

and discovery that leads to our current understanding of Earth's magnetic soul.

In each section she meets with a contemporary scientist researching a specific aspect of magnetism. She then uses their work as a springboard to dive into the history of that subject, discovering the adventurers and visionaries who played their part in uncovering the mysteries of magnetism. While some of the featured scientists are less endearing than others,

the book paints an intriguing picture of the process of scientific discovery.

In section one on the history of the magnet, for example, we are introduced to the brash and irritable modern geologist who's trying to revive the work of obscure French physicist Bernard Brunhes, the man who first proposed the idea that Earth's magnetic poles periodically and spontaneously swap around. The story then segues from the author's tour of French volcanoes in search of the rocks that inspired Brunhes' groundbreaking theory, back into the past to learn more about this pioneer of paleomagnetism.

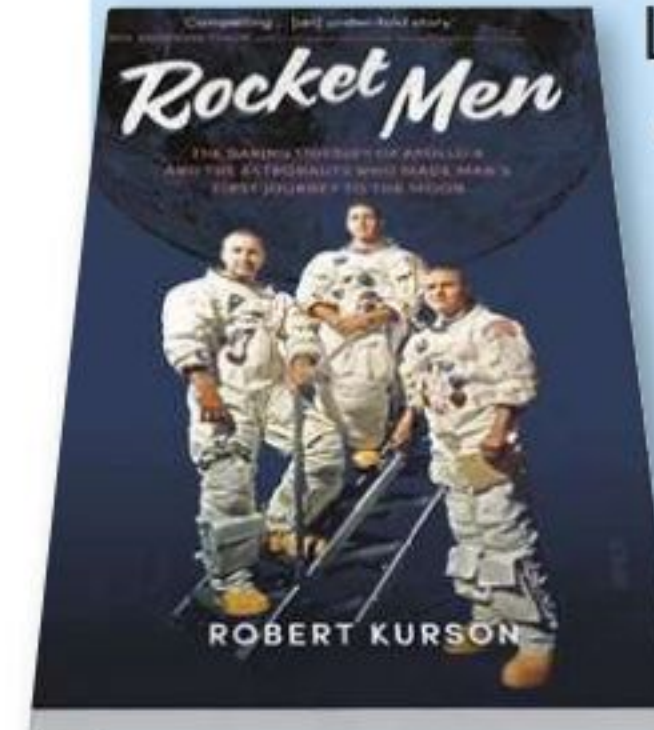
Although the book could have benefitted from some illustrations, it certainly stokes the reader's curiosity about one of the most critical but invisible forces in the Universe. *The Spinning Magnet* brings together the human aspect of science with a multitude of specialist fields to address some crucial questions: what is Earth's magnetic field, how is it generated and will it last forever?

★★★★★

DR HANNAH WAKEFORD is an astronomer who specialises in the study of exoplanet atmospheres at the Space Telescope Science Institute

Rocket Men

Robert Kurson
Scribe
£18.99 • PB



Last year NASA considered adding a crew to the 2020 translunar flight of its SLS rocket and Orion spacecraft. Ultimately it was decided that flying people on

an untested rocket and spacecraft would be too risky and expensive. Arguably caution was the right call, but in 1968 NASA took a riskier road: sending Apollo 8 – only the programme's second manned mission – all the way around the Moon.

Astronauts Frank Borman, Jim Lovell and Bill Anders became the first humans to leave Earth orbit, coming to within 112km of the Moon and vanishing behind it. Robert Kurson recounts this interplanetary voyage as an adventure; a specifically American one. The spaceflight is set within the tumultuous US history of that time. It is, for example, linked to the other feel-good story of Christmas 1968: the release of the USS Pueblo spy ship crew from North Korea.

Kurson shares vivid detail such as the crew's scramble to take the famous 'Earthrise' photo of our planet, or how they corrected a worsening spin using stationary zero-g dust motes floating within the cabin as a reference against the fast-rotating spacecraft walls.

Based on crewmember interviews, this is very much a history book – and something of a lost opportunity. After all, next decade lunar missions (and a proposed Deep Space Gateway) will take their cues from Apollo 8 not Apollo 11, based on lunar circumnavigations rather than landings. There are no lessons learned here, however; for all its readability, this book's perspective is on the past, not the future.

★★★★★

Spaceflight expert SEAN BLAIR writes for the ESA website

Gear

Elizabeth Pearson rounds up the latest astronomical accessories

1



1 Altair atmospheric dispersion corrector

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3 Tracer 12V 3.5A battery

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01442 822997 • www.tringastro.co.uk

Weighing only 600g, Tracer's lithium ion batteries are a great alternative to heavy power tanks and the digital gauge shows how much charge you have left. Comes with mains and car chargers.

4 ZWO mini guidescope

Price \$99 • Supplier ZWO • 00 86 512
65923102 • astronomy-imaging-camera.com

This ultra-lightweight and compact guidescope has 120mm focal length and should fit most findercope brackets. Compatible with all ASI cameras.

5 Explore Scientific Moon and planets filter set

Price £40 • Supplier Telescope House
01342 837098 • www.telescopehouse.com

These filters will help to bring out the contrast of the Moon and planets. They have an antireflection coating and are made of high quality optical glass.

6 Optics cleaning kit

Price £12.95 • Supplier Harrison Telescopes
01322 403407 • www.harrizontelescopes.co.uk

Designed specifically for cleaning astronomy optics, this kit contains a blower, lens tissues, cleaning fluid, microfibre cloth and cotton buds, as well as a screwdriver and tweezers.

4



5



6



2



3



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WHAT I REALLY WANT TO KNOW IS...

How do you study exoplanet atmospheres?



Giovanna Tinetti is the driving force behind an upcoming space mission to analyse exoplanets' atmospheres

INTERVIEWED BY PAUL SUTHERLAND

Thousands of exoplanets have been discovered orbiting other stars in recent years, showing that our own Solar System is by no means unique. Despite such a high number, there is still something of a mystery surrounding the nature of these alien planets and how they relate to their parent stars. Planetary scientists are keen to learn more about the physical characteristics of these fascinating worlds and whether there are any patterns to be found.

I am principal investigator for a new medium-sized mission selected by ESA called ARIEL (the Atmospheric Remote-sensing Infrared Exoplanet Large-survey) which will attempt to address this question by studying the atmospheres of exoplanets in detail. Observations with current instruments from space or on the ground have already indicated that we could learn the chemical compositions of some nearby exoplanets' atmospheres using these methods, but not with the level of accuracy that we need.

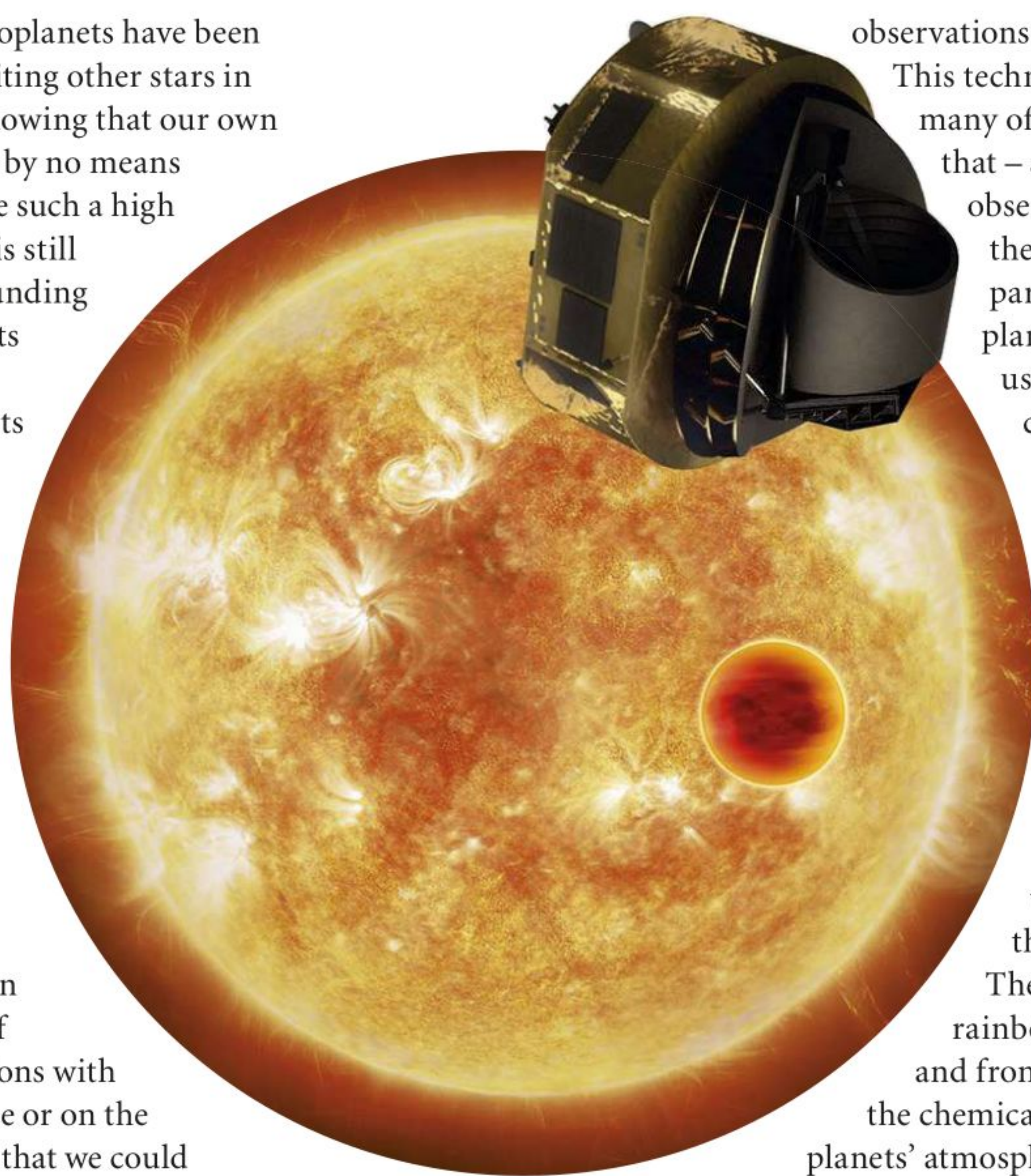
At the same time, we don't just want to gather this information for a few tens of planets; we really want to be able to explore the potential characteristics of these planets and their stars in large numbers. Doing so will help give us more of a statistical answer about the nature of exoplanets than if we just cherry-picked the best ones.

And that's where ARIEL comes in.

ARIEL analysis

ARIEL, due to launch in 2028, is a dedicated mission designed from scratch that will study 1,000 exoplanets over a four-year mission. It will be a one-metre telescope in space, sitting about 1.5 million km away from Earth, on the opposite side of the Sun. It will be able to look at exoplanets both in the visible light that our eyes can see and the infrared, where most of the gases' molecules can be detected.

The telescope will use the transit technique that has so far been very successful in delivering the first



The ARIEL mission isn't on the hunt for habitable exoplanets, but hot ones with dynamic atmospheres of circulating gases ready to reveal evolutionary data

ABOUT PROFESSOR GIOVANNA TINETTI
Giovanna Tinetti is Professor of Physics and Astronomy at University College London. Her special interest is in characterising exoplanets and their atmospheres to discover what they are made of

observations of exoplanet atmospheres.

This technique relies on the fact that many of these exoplanets have orbits that – at a certain point from the observer's perspective – carry them in front of or behind their parent star. Knowing where the planet is at a certain time enables us to add or to subtract the contribution that the planet makes to the star's light. In this way we can separate the light of the planet from the light of the star.

Hot spots

We will have a couple of spectrographs on the spacecraft that will enable us to analyse both the visible and infrared light from the planets that we observe.

These will split the light into a rainbow of different wavelengths, and from that we will be able to extract the chemical fingerprints of gases in the planets' atmospheres. That information will allow us to work out what molecules exist in each planet's atmosphere.

The planets we'll be observing will range from those comparable in size to Jupiter or Neptune down to super-Earths. Some of the planets may be habitable, but the mission's main focus will be on hot planets that orbit close to their home stars. This is because hot exoplanets offer us a natural laboratory in which we can study the chemistry and formation of exoplanets. The scorching heat keeps the molecules from various gases circulating in the exoplanets' atmospheres, whereas with cooler worlds, the different gases separate out and condense to form distinct cloud layers.

We expect that ARIEL's observations will tell us a lot about how exoplanets are formed and evolve, and how that evolution is linked to their host stars. There are a lot of predictions about what we might discover, but I am sure that we also will be surprised by many unexpected revelations. So although we are able to plan our studies, we may well have to be ready to rethink that plan when the actual observations start coming in. **S**

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THE SOUTHERN HEMISPHERE IN AUGUST

With Glenn Dawes

WHEN TO USE THIS CHART

1 AUG AT 00:00 UT
15 AUG AT 23:00 UT
30 AUG AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as the stars crossing it set four minutes earlier each night. We've drawn the chart for latitude -35° south.

AUGUST HIGHLIGHTS

Comet C/2016 M1 (PANSTARRS) has been moving southward in recent months and is predicted to be at mag. +9 dropping to mag. +10 over August. It won't be spectacular but will be well placed for southern hemisphere observers. The comet spends the month near Alpha Centauri, moving from 7° northeast to 3° northwest from the star. On 19 August Comet C/2016 M1 passes between two open star clusters, NGC 5662 in Centaurus and NGC 5715 in Circinus.

STARS AND CONSTELLATIONS

The teapot of Sagittarius crosses overhead from mid-latitude Australia in the early evening in August, bringing the prominent central bulge of the Milky Way with it. Spectacular views of our galaxy stretch from the southwestern horizon near the false cross of Carina and Vela all the way to Cygnus in the northeast. To view the other half of the galaxy you need the anticentre (in Taurus) close to overhead. This requires a trip to the Northern Hemisphere around February.

THE PLANETS

A parade of bright planets continues in the evening sky. Venus is still well above the western horizon at the end of twilight. Looking north you'll find Jupiter, which spends most of August within 1° of the star α^2 Librae. You'll find Saturn near

Sagittarius's Teapot and transiting around midmonth. Mars follows Saturn two hours later. The Moon does a nice job touring these worlds, with conjunctions with Venus on 14 August, Jupiter on 17 August, Saturn on 21 August and Mars on 23 August.

DEEP-SKY OBJECTS

This is a good time to visit the 'Tail of the Serpent' constellation, Serpens Cauda. The tail ends at mag. +4.6 Theta (θ) Serpentis (RA 18h 56.2m, Dec. $+04^\circ 12'$). It is a brilliant double star, formed by two hot blue/white components of mag. +4.5 and +5.0 separated by a leisurely 22 arcseconds.

Moving 20° south-southwest you'll find a very rich galactic region.



Within lies the Eagle Nebula M16 (pictured), its most observable feature being the open star cluster NGC 6611 (RA 18h 18.8m, Dec. $-13^\circ 47'$). This mag. +6 collection of around 40 stars is spread over a circle of 0.1° with a clustering to the northwest. The brightest members are mag. +8. The cluster is covered in bright nebulae which are shaped into a distinctive 'V' by a dark lane intruding from the north.

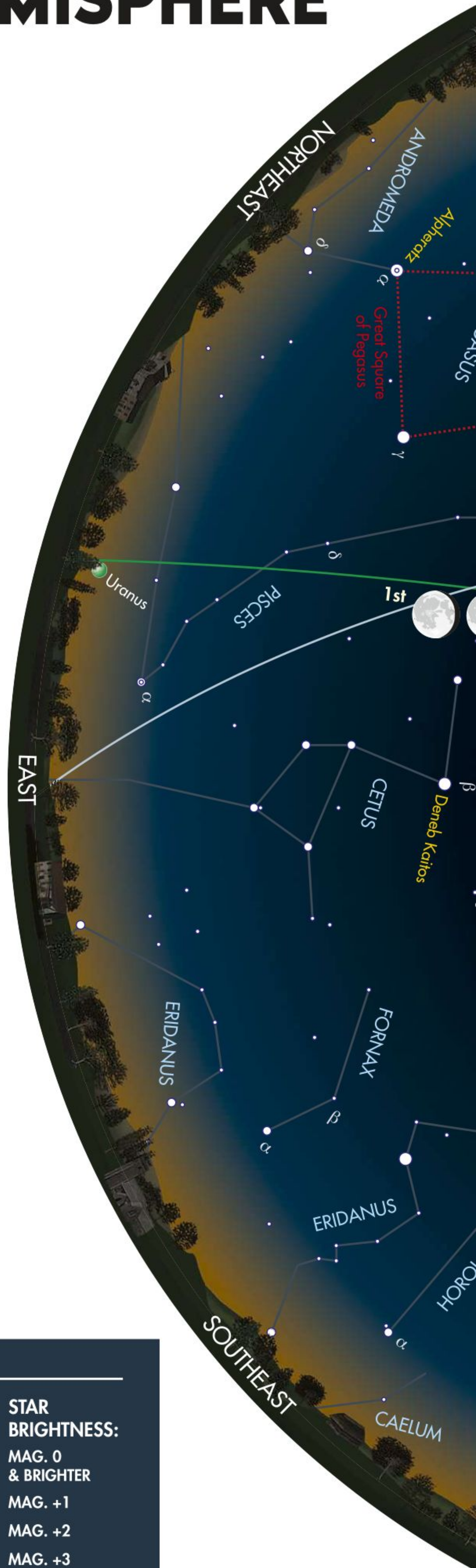
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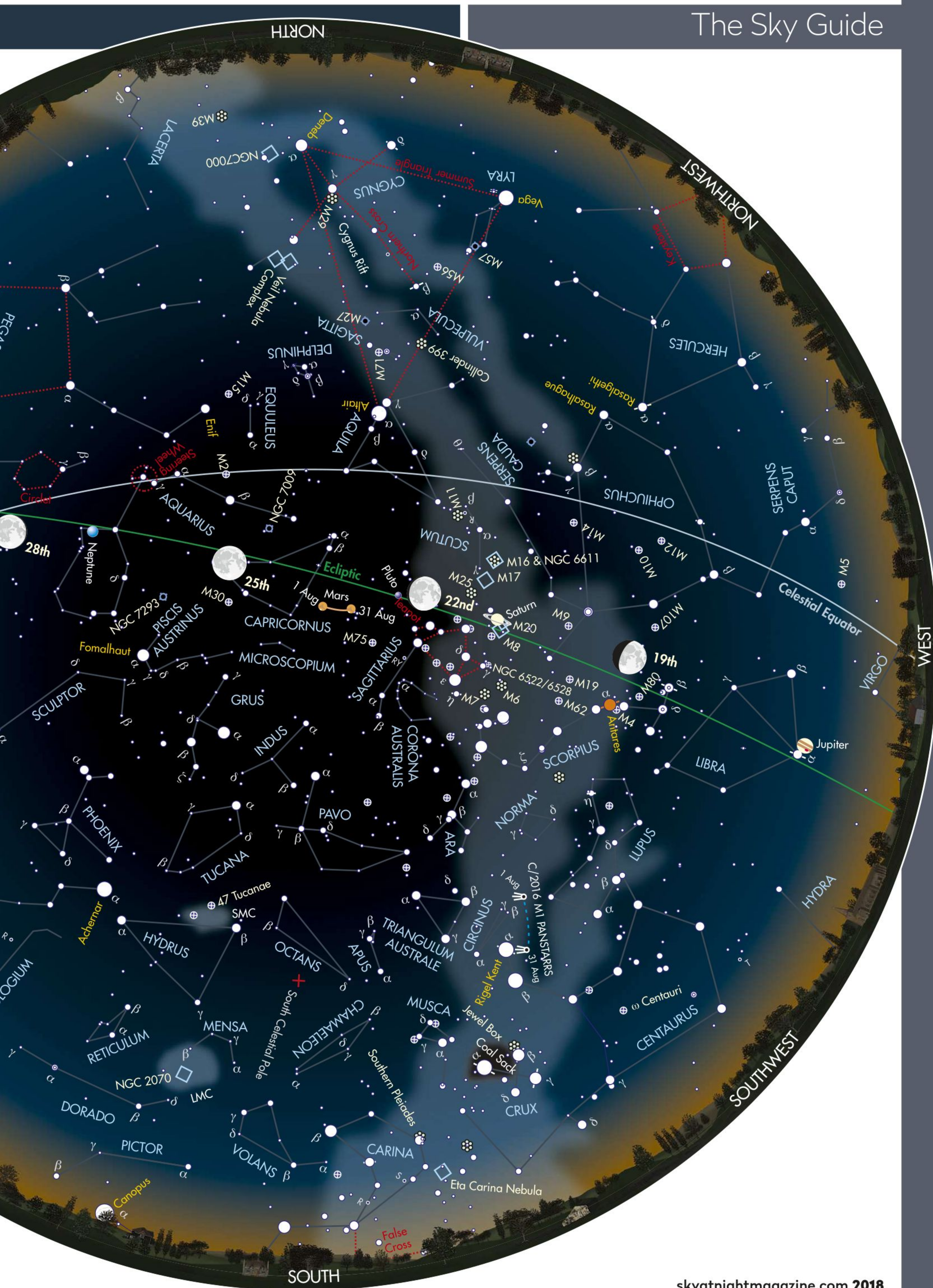
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA

- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK

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- METEOR RADIANT
- QUASAR
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- STAR BRIGHTNESS:**
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 - MAG. +1
 - MAG. +2
 - MAG. +3
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BBC Sky At Night Magazine (July '09 Issue)



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NEWTONIAN REFLECTOR

Standard Specification

- Magnifications (with eyepieces supplied) x30, x60, x75, x150
- Highest Practical Power (Potential) x300
- Diameter of Primary Mirror 150mm
- Telescope Focal Length 750mm (f/5)
- Eyepieces Supplied 10mm & 25mm
- 6x30 Finderscope • Fully GO-TO Upgradeable
- x2 Deluxe Barlow Lens • Parabolic Primary Mirror
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- EQ3-2 Equatorial Mount with Aluminium Tripod
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*"Good for advanced observing".....
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SRP £379

OTA SRP £199
EQ3-2 SRP £199

EXPLORER-150PL (EQ3-2)

150mm (6") f/1200
PARABOLIC NEWTONIAN REFLECTOR

Standard Specification

- Magnifications (with eyepieces supplied) x48, x96, x120, x240
- Highest Practical Power (Potential) x300
- Diameter of Primary Mirror 150mm
- Telescope Focal Length 1200mm (f/8)
- Eyepieces Supplied 10mm & 25mm
- x2 Deluxe Barlow Lens
- 6x30 Finderscope
- Parabolic Primary Mirror
- 0.5mm Ultra-Thin Secondary Mirror Supports
- Fully GO-TO Upgradeable
- EQ3-2 Equatorial Mount with Aluminium Tripod
- 33% more Light Gathering than 130mm



"Verdict: a reborn classic that I can't recommend highly enough for the price.."
Ade Ashford,
www.scopetest.com

ADVANCED FEATURES All Sky-Watcher f/4 & f/5 Newtonian Reflectors feature high quality Paraboloidal primary mirrors to eliminate spherical aberrations, producing sharp, contrasty images, which are full of detail. In addition they feature 0.5mm Ultra-Thin secondary mirror supports to reduce diffraction spikes and light loss. All Sky-Watcher reflectors are Multi-Coated with Silicon Dioxide as standard for Optimum Durability and Long Term Performance.

Sir Patrick Moore Endorsed Sky-Watcher Telescopes



"I have used a great number of telescopes; some are good, some mediocre and some bad. To me the Sky-Watcher range of instruments are very good indeed, & suited to amateurs of all kinds - and they are not priced out of the market! Excellent value. Use them and enjoy them."
Sir Patrick Moore CBE FRS (1923-2012)

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